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A STUDY OF THE FACTORS ASSOCIATED WITH SUCCESSFUL TECHNOLOGY TRANSFER AND THEIR APPLICABILITY TO AIR FORCE TECHNOLOGY TRANSFERS

THESIS

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THESIS

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Master of Science in Contracting Management

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The creator of a research concept and the author are often separate entities. In this case, the creators of this research stream are the individuals that comprise the partnership between the Air Force Material Command Technology Transition Office's Technology Transfer Division and the Air Force Institute of Technology, both located at Wright-Patterson Air Force Base, Ohio. Namely, Tim Sharp, Chief, Technology Transfer Division and my faculty advisor, Major Richard Franza, Program Director, Graduate Systems Management, Graduate School of Logistics and Acquisition Management, Air Force Institute of Technology. The author appreciates the partnership's perfect measure of guidance and latitude. Their efforts made the thesis "experience" richly rewarding.

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James B. Rose

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Abstract

Although the United States is a world leader in scientific research, it lags behind some economic powers in the application of technologies. As quality and manufacturing excellence were critical to US competitiveness in the 1980s, so is commercializing technologies in the 1990s. With billion dollar budgets and exceptional scientific talent, the potential for fruitful technology transfer is abundant.

By definition, federal-to-commercial technology transfer is the ability to leverage national investments in technology beyond their traditional customer base. The technology can be physical devices, processes, knowledge, or proprietary information. Unfortunately, and despite exhaustive legislative efforts, US industry has fallen behind its competitors in the application of federal technologies to commercial uses. However, research indicates that some organizations routinely experience successful technology transfer actions. In fact, studies identify a gap between the technology transfer rates of some universities and government laboratories.

The objective of this thesis effort is to pinpoint techniques which may improve Air Force technology transfer. First, previous literature is utilized to identify attributes associated with successful technology transfers. Surveys, which define the presence of successful attributes, are personnally administered to key individuals on acquiring and developing teams of Air Force laboratory sponsored technology transfer projects. Data from 19 technology transfer projects are analyzed. Results of the analysis pinpoint techniques which can be used to improve Air Force technology transfer strategies.

A STUDY OF THE FACTORS ASSOCIATED WITH SUCCESSFUL TECHNOLOGY TRANSFER AND THEIR APPLICABILITY TO AIR FORCE TECHNOLOGY TRANSFERS

I. Introduction

Research Objectives

The objective of this research is to pinpoint techniques which may improve Air Force technology transfers. Previous literature reveals that some organizations practice successful technology transfer strategies and techniques that increase the number and likelihood of commercializing viable technologies. Furthermore, improvements in Air Force technology transfer techniques can have substantial impact for several reasons. First, improving Air Force technology transfer results in direct stimulation of the economy. Federally developed technologies can be a low to moderate risk venture to the producer relative to internally developed technologies. This form of federal cooperation can help corporations compete against international competitors that may be subsidized by their country. In addition, the current administration has emphasized the desire to benefit both federal and private sector economies with government research and development funds. This is increasingly important and equally controversial as federal budgets decrease and research and development funding shrinks.

The research objectives are as follows:

1. Identify successful technology transfer techniques and processes.
2. Identify Air Force laboratory technology transfer techniques and processes present in the sample population.
3. Develop a means to analyze Air Force methods against successful methods.
4. Identify necessary and/or sufficient conditions for successful technology transfer.

5. Identify strategies for the Air Force to implement to improve transfer success.

The focus of this effort is upon factors that influence successful technology transfers throughout the transfer project *life-cycle*. Emphasis is upon characteristics of the transfer projects during its execution and not optimal approaches for *establishing* technology transfers.

Definitions

Technology transfer has multiple definitions. For this research, technology transfer is the transfer of physical devices, processes, knowledge, or proprietary information from one organization or institution to another (4:232). Technology transfer can occur between organizations within a single company. This is known as internal technology transfer. Likewise, external technology transfer occurs between two non-related organizations. For this study, concentration will be focused upon external technology transfer from federal laboratories (Air Force technology developers) to commercial industry. Technology transfer, as it relates to national security or international barter, is not relevant to this study.

Transferring of ideas and knowledge between organizations has occurred throughout history. Most view the exchange of technology like a relay race, where one runner passes the baton to the next. Richard Dorf describes in "Models for Technology Transfer From Universities and Research Laboratories" that technology transfer is most like basketball, where the ball is passed back and forth among team members in pursuit of a score (9). Figure 1-1 diagrams the interactive process of the technology transfer team members (8:181).

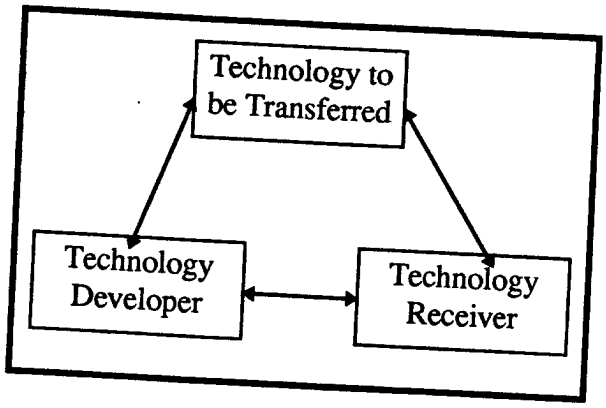

Figure 1-1. Technology Transfer Process Interactions (8:181)

The two primary parties that comprise each team are the developers and the acquirers. Federal laboratory personnel are identified as developers because the technologies transferred to the private sector originate in their laboratories. Private sector firms are the receiving team and thus categorized as acquirers. Not all sample technology transfer actions disclosed in Chapters Three and Four fit the classic mold of federally developed technologies transferred to the private sector. In some samples, the transfer action is federal laboratory evaluation of existing or developing commercial products, or federal laboratory maturation of commercially developed technologies. Regardless of the nature of the transfer actions, federal laboratory personnel will be consistently identified as developers and private industry personnel as acquirers.

Thesis Overview

Chapter Two focuses upon significant literature addressing technology transfer processes. Included in this section is a summary of federal technology transfer legislation of the 1980s and 1990s. The literature review is utilized to assimilate successful attributes identified in previous research efforts. The methodology of this exploratory study is explained in Chapter Three. This chapter focuses the reader on the research methods and

logic behind the findings. Based upon the successful attributes identified in Chapter Two, a survey instrument is developed to define the presence of successful attributes in sample transfer actions. Interviews with technology specialists belonging to developing and acquiring teams provided answers to survey questions. Chapter Four presents results of data analysis and Chapter Five summarizes conclusions, strategies for Air Force implementation, and areas for future research.

II. Literature Review

Introduction

This chapter synthesizes significant literature concerning federal technology commercialization efforts. Specifically, it compiles results from studies of technology transfer processes. The three critical processes are technology transfer modeling, identifying attributes of technology transfer, and measuring transfer success. These processes have been identified as significant elements to understanding technology transfer success. Responsibility for federal difficulties in applying successful process improvements may be attributed to a lack of understanding regarding the three critical processes (19:63). Federal performance has created a disparity in transfer success as compared to entities such as universities and commercial organizations (5:21). Identifying the process attributes that account for transfer success will provide insight for improving the transfer methods of the Air Force and other federal agencies.

Background

For decades, the political and economical implications of successful technology transfer have become apparent. In the 1960s, the "space-race" tested our technological capabilities. In the early 1970s, President Nixon spoke of the need to establish active federal to commercial technology transfer to best utilize vast federal research and development budgets (13:9). However, it was not until the early 1980s, when successful foreign products disrupted the balance of international trade, that technology transfer became a political and strategic priority. The anxiety caused by increased foreign competition, and the subsequent domestic technological stalemate, resulted in legislative action directed towards reviving the commercial impact of federal laboratory technologies.

Motivation

In the early 1980s, it became evident that although the US was a world leader in scientific research, it was lagging behind other economic powers in the application of new technologies (1:A-1). The future implications were frightening enough to stimulate Congress to make technology transfer a national strategic priority. Sinking US innovation rates were affecting the nation's economy and standard of living. Appendix A documents the results of the evolution of US federal to commercial technology stimulus legislation (1:A-5,A-6). The legislation has two distinct phases. The first phase (early 1980s) strives to make commercialization of federal technology a common goal of Government Laboratories. The second phase, beginning with the 1986 Federal Technology Transfer Act, sought to establish a framework to enhance transfers. This phase focused on cooperative research and development as a vehicle for technology transfer (3:242).

The legislation was a direct reaction to foreign economic competitors applying principles the US neglected to practice. One principle postulates that skilled use of technology creates wealth. And technologies create products that people wish to buy and processes to make those products better (2:273-274). Legislation attempted to stimulate federal to commercial technology transfer in order to increase national wealth and competitive position. The belief was that valuable federally developed technologies lay waiting for commercialization (2:273-274).

At issue is the $15-$25 billion dollar research and development budget that supports over 700 federal laboratories. Federal laboratories are rich research and development resources, which, if exploited properly, can boost US competitiveness (3:239). For instance, federal laboratories received $25 billion of a $71 billion annual federal research and development budget in 1991. During the same period, industrial research and development expenditures were similar--$72 billion (5:8). In addition, the federal laboratories are responsible for generation of approximately 30,000 patents issued

in 1991. By exploiting these innovations, the US reaps a better return on federal research investments. The exploit potential of federal research facilities is significant. Consider billion dollar budgets and the exceptional scientific talent (over 100,000 scientists have at least 20 years of experience) (5:8). The bad news is that less than 5 percent of federal patents have been developed into commercial products (1:A-1).

Previous research pinpoints a gap between technology transfer rates of some universities and government laboratories. For instance, in 1990, the Massachusetts Institute of Technology (MIT) granted the same number of technological licenses as the entire Department of Energy (DOE) laboratory system. MIT earned twice as much royalty income as the DOE while spending 1/10th the DOE budget. Stanford University and the University of California have comparable figures to MIT. The universities' technology transfer processes are the primary reason for this disparity (5:9).

Federal agencies argue that process is not the sole reason for this disparity. In the past, conviction that federally developed technologies are public domain undermined technology transfer efforts. Policy of the previous decades supported this assumption by emphasizing wide disbursement of Government technology. This concept of diffused ownership undermines technology transfer by acting as a barrier to corporations wary of investing their own funds in community technology. Fortunately, legislation has eliminated these practices, but industry perceptions have been slow to respond. Although government laboratories may have unique problems, process remains the key to improving technology transfer rates (5:21).

Numerous books and articles have been written on the process of technology transfer. Technology transfer related publications address technology selection, process models, successful techniques, and case studies. Some of the research relates to federal agency transfer needs, but little work has synthesized the research and applied the results to defense technology transfer efforts. The question remains: How can one utilize the data

already available to improve DOD/Air Force technology transfer methods? The answer may lie in identifying the critical process variables that trigger successful technology transfer.

Dr. Robert Carr, in "Doing Technology Transfer in Federal Laboratories," identifies three process variables that successful commercial firms and universities have adopted that federal laboratories have not reacted to as effectively (5:21). The process variables are transfer process modeling, successful attribute identification and implementation, and transfer result measurement. Table 2-1 illustrates the three process variables.

Table 2-1. Critical Process Variables of Successful Organizations

1. Modeling the transfer process
2. Identifying and implementing successful technology transfer attributes
3. Measuring transfer outcomes

First, the Massachusetts Institute of Technology, along with other universities with high technology transfer rates, practice market-based models of technology transfer. Most federal laboratories and less successful universities practice legal or administrative transfer models. Some federal organizations have implemented marketing methods with remarkable success (5:9). The marketing, legal and administrative models are named after the organizational approach of the dominant business function controlling the technology transfer process. Second, organizations that adopt proven successful transfer techniques have opportunities for improved technology transfer rates of success. Third, the capability to measure, benchmark, and track technology transfer results in process and product improvements. Spann, Adams, and Souder, in their study on improving federal

technology commercialization, explain that low rates of federal transfer may be the result of inability to reach consensus on how to define, track, and measure transfer progress and success (19:63).

Chapter Outline

The remainder of this chapter will expand upon the three process variables that can facilitate improved federal technology transfer. This includes contrasting the different technology transfer models utilized by federal and commercial organizations. In addition, the key attributes of successful technology transfer will be highlighted in order to gain a better understanding of the range of transfer methods. Finally, procedures for measuring technology transfer success will be outlined. The motive for this scope of research is to gain an understanding of attributes of successful transfer which can be applied to Air Force transfer methods. These attributes will also serve as a tool for comparing existing Air Force, federal agency, and commercial technology transfer techniques against a benchmark of successful attributes. This comparison will provide insight into the application of alternative methods in the future.

Technology Transfer Models

Assessing technology transfer is complicated by difficulties in determining the time, circumstances, and degree of success of particular transfer actions. Identification of a process model should provide a better understanding of the critical elements requiring evaluation. Complementary research exists on technology transfer models. Robert Carr emphasized an evolving model developed by Jon Sandelin of Stanford University's Technology Licensing Office. Sandelin's models mimic the organizational approach of the dominant business function controlling the technology transfer process. The models he identifies are the legal model, administrative model, and the marketing model (5:15).

The legal model transfer program originates in an organization's patent office. The legal departments that manage these offices are most concerned with the control and ownership of the technology rather than rates of transfer. As a result, organizations using this method experience low transfer rates. The administrative model transfer programs began as a result of technology transfer legislation. The managing offices examine the commercial opportunity of technologies, but marketing is usually limited to trade publication advertisements. On the other hand, the marketing model technology transfer offices actively market technologies with an entrepreneurial staff of technology experts trained in marketing. While Sandelin's models are named based upon the dominant organization function, other models are identified by their process characteristic.

Gibson and Niwa identify the communication-based model, cognitive mapping, and the Technology Transfer Continuum (developed by Digital Equipment Corporation) as fundamental approaches to transfer modeling (11:179). The communication based model (Figure 2-1) describes a continuous, interactive process between developers and acquirers.

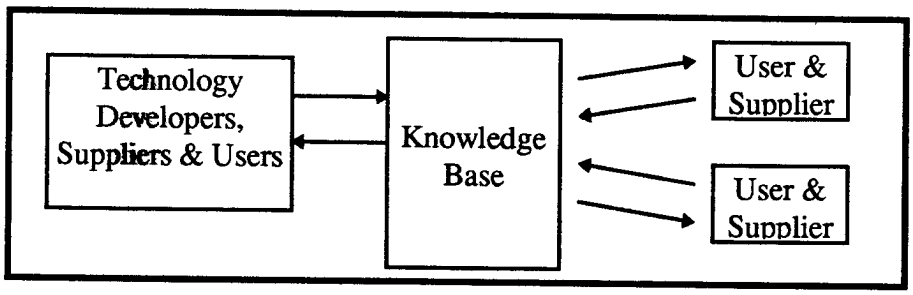

Figure 2-1. Communication-Based Model (11:179)

In this model, the organizational lines between developers and acquirers are blurred, emphasizing the necessity for both functions to work as one (11:179). Cognitive mapping strives to improve the quality of technology transfer decisions. This model illustrates the

perceptions of the various parties in a decision environment. Digital Equipment Corporation's Technology Transfer Continuum (Figure 2-2) explores the continuous involvement of all internal functional areas from corporate research to integration with the external developer. This dynamic process involves the entire corporation (8:181). All three models help visualize technology transfer as a continuous, evolving process, incorporating every aspect of a corporation.

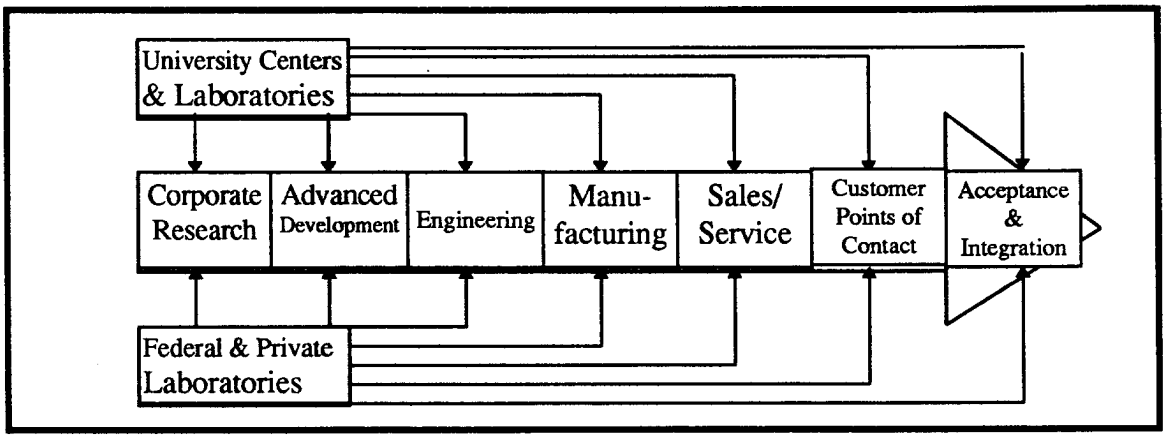

Figure 2-2. Technology Transfer Continuum (8:181)

Robert Carr identifies models of transfer measurement (5:19). These models address how organizations measure the success of their programs. The out-the-door model counts transfer actions as units. This measures the number of solicitations or Cooperative Research and Development Agreements (CRDAs). Likewise, the market impact model measures the technology in relation to the market. The model exams the predicted impact the technology will have in market(s). Such measurements may be jobs created, sales generated, stimulus to local economy and so forth. Federal laboratories may measure expected commercial sales and/or subsequent royalty payments. The political model stresses bureaucratic successes and achievements in fund authorizations. Last, the opportunity cost model examines relative technology expenditure in relation to alternate

uses for the funds (5:20). A similar study by Bozeman and Coker define "out-the-door" as a method for determining the effectiveness of technology transfer (3:244). Organizations that measure the quality of their program by the number of technologies that go "out-the-door" may be oversimplifying a complex measurement. If the technology results in no beneficial effect or if the adopting organization allows the technology to lie dormant, then what benefit has society received?

The marketing model best translates federal transfer objectives. Much of the legislation depicted in Appendix A addresses the primary objective of federal to commercial technology transfer. The primary objective is to best utilize federal research and development funds through the transfer of federally developed technologies to the private sector. Successful commercial application of federally developed technologies can stimulate national economies and increase competitiveness. If success in technology transfer occurs upon product financial success, or some other type of economic benefit, then the marketing model's outlook on economic factors such as sales, market share, and royalties best identifies federal objectives.

Mere identification of transfer process models provides little insight into methods by which to improve federal technology transfer efforts. The question must be asked; what transfer model suitable for federal laboratories can improve transfer success? Robert Carr postulates that the key reason for the lack of federal technology transfer success, in comparison to university transfer efforts, is wariness of federal labs to utilize the marketing model (5:22). With marketing model technology transfer offices thriving, what opportunities do federal laboratories have for implementing these procedures? Robert Carr purports that federal laboratories can implement some successful marketing model methods. But an entrepreneurial marketing organization is not the only attribute an organization needs for a successful technology transfer program. The next section will

highlight the practices exhibited by various successful and unsuccessful technology transfer organizations.

Attributes of Federal and Commercial Technology Transfer

Identifying success and barrier attributes to technology transfer is a logical evolutionary step. An extensive look at federal technology commercialization efforts can be found within the database of the National Comparative Research and Development Project (NCRDP). The NCRDP was initiated at Syracuse University in 1984 and has grown into a multinational project sponsored by numerous government organizations. Responses to questions on numerous technology issues were collected from over 900 public and private laboratories (3:247). Crow and Bozeman focused on a sub-sample of NCRDP data consisting of 134 government laboratories and 139 university laboratories. The survey results revealed that laboratories that engage in technology transfer tend to exhibit common characteristics. The five identified characteristics of federal laboratories are: 1) vulnerability to market changes, 2) large overall personnel pool, 3) large scientific personnel pool, 4) externally oriented lab director, 5) diverse R&D missions (4:241). A parallel study by Bozeman and Coker concludes that, multifaceted, multi-mission labs are more likely to exhibit technology commercialization success.

While Bozeman, Coker and Crow examined federal laboratories, O. Lew Wood and Errol P. EerNisse research technology acquisition from the commercial industry perspective (20:24). Industries that successfully acquire technology, from both Government and private sources, exhibit common transfer actions. These actions are basic steps required for successful transfer. The eight steps are: 1) identify the need, 2) evaluate the source of the technology, 3) assess the technology, 4) efficient acquisition of the technology, 5) finance the project, 6) transfer the technology, 7) implementation, 8) termination (20:24). An important distinction is made between step 4 (acquisition of the

technology) and step 6 (transferring the technology). Step four encompasses the legal hurdles, such as agreement to the terms of a license or cooperative agreement. Step 6 is the actual exchange of knowledge, know-how, or technologies. Their research reveals that successful technology transfers are dependent upon the relationship between the transfer methods of the host organization, the acquiring organization, and the traits of the technology itself. This information coupled with Bozeman and Coker's results illustrate the critical relationship between developer, acquirer, and the technology.

Chairman Wood and President EerNisse of Quartex Inc., illustrate the critical interactions of the three primary parties involved in technology transfers (developer, acquirer, and technology). They examined a specific technology transfer act between Sandia National Laboratory and Quartex, Inc., in hopes of identifying critical elements applicable to successful transfers (20:23). Sandia National Laboratory is a Department of Energy laboratory and Quartex, Inc. was founded in 1978 to pursue commercialization of transducer technologies. In this case, Quartex effectively identified a technology at Sandia that fit a strategic objective within their organization. They acquired the technology and the inventor from the laboratory, and within two years concluded four major business arrangements in four separate industries (20:25). Wood and EerNisse identified the success factors involved in this particular federal to commercial transfer. Success was attributed to factors such as diverse market applications, technological fit, watershed invention, and capability to improve technology (20:25).

Attributes of Successful Technology Transfer. Appendix B compiles this study's baseline of successful transfer attributes. Significant contributing research is displayed in tables 2-2 through 2-6. Each table summarizes contributions to this study's baseline of successful attributes. As Wood and EerNisse explain, successful technology transfer is dependent upon the relationship of the developer, acquirer, and the technology. To facilitate data analysis (Chapter Four), successful attributes are identified by the

principal party(s) they address. Each attribute and sub-attribute in Appendix B is precluded with the letters "D", "A", "T", or any combination thereof. These letters identify the technology transfer party the attribute addresses. Developers (D), Acquirers (A), and Technology (T) are the principal parties.

Several primary attribute titles are this author's attempt to compile similar sub-attributes obtained from other research. Therefore, some primary attribute titles do not originate from research depicted in tables 2-2 through 2-6. Likewise, some sub-attributes expand the original scope of attributes identified in previous literature. Again, some sub-attributes appearing in Appendix B do not appear in Tables 2-2 through 2-6.

In Chapter 3, survey questions are linked to attributes and sub-attributes from this list. The survey questions indicate the presence of successful attributes in a sample of technology transfer actions. From this information, recommendations are formed for improving Air Force rates of successful technology transfer. Ensuing paragraphs, beginning with a summary of contributions from Wood and EerNisse, abstract contributing research and disclose findings via tables.

Table 2-1 highlights successful attributes utilized by this study originating from the research of Wood and EerNisse.

Table 2-1. Attributes of Successful Technology Transfers (Wood and EerNisse)

Attribute	***Attribute Title***
1b	Resources are made available to actively seek technology transfer opportunities. (D,A)
3c	Technology "champion" is present. (D)
9a	Organization has completed technology transfers. (A)
13a	Tangible value -- new technology, when compared side-by-side with status quo provides noticeable improvement. (T)
13c	Diverse market applications. (T)
13d	Exclusive property rights (patents) obtained or obtainable. (D,A)
13e	Ability to improve proprietary coverage is possible. (T)
14a	The technology is presented at a time when the organization can commit resources. (A)
14b	The technology matches the technological capabilities of one of its operating units and one of its operating markets. (T,A)
14c	Personnel have capability to understand, maintain, and further develop technology on its own. (A)

The research of Wood and EerNisse focused primarily upon technology transfer organizations. The next step is to discover the critical factors in taking federal technology to the market. Robert Carr, in his article "Menu of Best Practices in Technology Transfer (Part 2)," conducted a series of interviews with technology transfer professionals at select federal and university laboratories. His research identified methods and techniques recommended for any laboratory wanting to adopt a "full-court press in technology commercialization" (6:24). In retrospect, his concepts may not appear revolutionary, but

it is a significant attempt to categorize the keys to transfer success. His product includes suggestions for involving and recognizing inventors, maximizing inventor disclosures (and subsequent patents), marketing strategies, technology evaluation, and emphasizing local area technology transfers (6:24-29). Table 2-3 summarizes attributes from this study emanating from Dr. Carr's research that will be utilized by this study.

Table 2-3. Attributes of Successful Technology Transfers (Dr. Robert Carr)

Attribute	***Attribute Title***
1	High level commitment (to overall technology transfer policy). (D,A)
2	High level commitment (to specific transfer). (D,A)
3	Informal transfer processes. (D,A)
3a	Organization structure facilitates informal technology transfer processes. (D,A)
5a	Developer and acquirer are located near one another. (D,A)
6g	Acquiring organization is large enough to handle all functions of product development, project control, manufacturing, and marketing. (A)
7c	Tech. transfer strategy involves the inventor in the tech. transfer process. (D)
7d	Inventor allowed to dedicate "corporate" time to the transfer project. (D)
8a	Organization has a technology transfer organization. (D,A)
10a	Marketing and advertising of technologies targeted to relevant industries. (D)
10b	Technology maturation supported by internal units or by contracting out. (D,A)
10c	Cooperative agreements and incentive arrangements encouraged to facilitate technology transfer. (D)
11a	Developers (scientists/technologists) participate in the technology transfer process. (D)
11b	Developers have incentives to see technology commercialized. (D)
11c	Scientists and engineers (potential developers) are encouraged to develop commercializable technologies. (D)
11e	Lab. has a formal recognition process for developers and key individuals. (D)
12b	Organization has a dedicated support staff for the patenting process. (D)
12c	Outside experts allowed access to identify tech. attractive to industry. (D)
12d	Market research is done in-house, or by contract, on tech. applications. (D)

Souder, Nashar, and Padmanabhan continue this stream of research by identifying best technology practices and characteristic traits of the actual technology (18:9). It is not sufficient to link successful attributes of the developer and acquiring organizations. The technologies themselves must be evaluated. Technologies that reveal the most post-transfer success are adopted by the user at several plants, locations, and departments. Many of the technologies are gateways for other technologies. As an example, the authors cite the steam engine as a gateway technology to many other technologies. Likewise, technologies modified for multiple use have the largest number of adaptations and variations. In addition, successful technologies usually add monetary or intrinsic value. Ultimately, successful technologies influence for an extended period of time (18:9). Table 2-3 summarizes Souder, Nashar, and Padmanabhan's contribution to the list of successful transfer attributes (Appendix B).

Table 2-3. Attributes of Successful Technology Transfers (Souder, Nashar, and Padmanabhan)

Attribute	*Attribute Title*
2b	Technology transfer project granted adequate financial and personnel resources. (D,A)
3b	Procedures are in place for requesting funds for technology transfer projects. (D,A)
3c	Technology "champion" is present. (D)
4	Strategic fit. (D,A)
6a	How technology transfer projects are staffed. (D,A)
6f	Technology developing organization is large enough to handle all functions of research and project control including marketing products and technology. (D)
10c	Cooperative agreements and incentive arrangements encouraged to facilitate technology transfer. (D)
13a	Tangible value -- new technology, when compared side-by-side with status quo provides noticeable improvement. (T)
13b	Divisibility--technology can be brought to the market in smaller, less dramatic, less risky forms. (T)
15a	Interface maintained between organizations. (D,A)

Raymond Radosevich and Suleiman Kassicieh in their article "Strategic Challenges and Proposed Responses to Competitiveness Through Public Sector Technology," identify critical technology transfer issues as strategic challenges (14:35). The research identifies nine strategic challenges that represent the "difficulty and urgency of action required to improve the process" (14:35). In addition, they propose responses to the strategic challenges that must be addressed by technology transfer implementors. Table 2-4

highlights attributes or sub-attributes emanating from the research of Radosevich and Kassicieh.

Table 2-4. Attributes of Successful Technology Transfers (Radosevich and Kassicieh)

Attribute	***Attribute Title***
1c	Management has a written, formal plan for promoting technology transfer. (D)
10b	Technology maturation supported by internal units or by contracting out. (D,A)
12a	Organization has incentives for identification of intellectual property. (D)
15b	Incentives provided to developing organization personnel are structured to encourage cooperation after initial commercial development and throughout the product life-cycle. (D,A)

In a paper to the 19th Annual Meeting of the Technology Transfer Society, William H. Fieselman and Ronnie D. Crutcher propose a method for rating potential technology transfer prospects. The method called the Transfer Opportunity Potential System (TOPS) compares technology transfer candidates. The system evaluates developers, acquirers, and the technology. The backbone of the system is questions that probe for characteristics present among the transfer participants. The questions address successful attributes beneficial to technology transfer actions. Therefore, Fieselman and Crutcher's research contributes attributes of successful technology transfer. Table 2-5 summarizes the findings included in this effort's baseline of successful transfer attributes.

Table 2-5. Attributes of Successful Technology Transfers (Fieselman and Crutcher)

Attribute	*Attribute Title*
6a	How technology transfer projects are staffed. (D,A)
6b	How technology transfer projects are funded. (D,A)
6c	Facilities in place for developmental research and production. (A)
6d	Organization has, on staff, personnel experienced in the subject technology. (A)
6e	Organization has personnel experienced in development and production. (A)
6f	Technology developing organization is large enough to handle all functions of research and project control including marketing products and technology. (D)
7a	Closeness of the transfer agent to the developing organization. (D)
7e	Organization has completed technology transfers. (D,A)
9b	Formal process plan exists for receiving technologies. (A)
9c	Business plan exists for commercializing technology. (A)
15c	Acquirer sought input from developer during cost and schedule estimate formulation. (D,A)

Barriers to Technology Transfer. A study of the keys to success is not complete without an understanding of the challenges and barriers to technology transfer. Although most studies on the barriers to commercialization of federal technologies produce lists too lengthy to cite, barriers can be categorized into major groups. Spann, Adams, and Souder identify the "underlying dimensions of technology transfer barriers" in a study culminating in recommendations for improved federal technology commercialization (19:63). The research discloses the underlying dimensions as adopter resistance, lack of adopter knowledge, government shortcomings, and distrust (19:67). Additionally, Robert Carr in

"Doing Technology Transfer in Federal Laboratories," divides his "factors that limit technology" in two groups: cultural and structural (5:17). The cultural limits are barriers caused by general misunderstanding of transfer partner needs and motives. Structural limits emanate from Government requirements to protect national security, provide equal opportunity and access to technologies, protect conflict of interest, and provide preference to domestic firms (5:18-19). The structural limits require industry to deviate from normal business practices, thus inhibiting the free flow of information between federal laboratories and private entities. Bureaucracy and the structural limits it creates inhibits adaptation of successful commercial technology transfer practices.

A 1991 survey of members of the Technology Transfer Society concluded lackluster commercialization of federal technologies is the result of a lack of government commitment and similar lack of interest from industry (20:24). The research identifies three areas where impediments originated. The impediments relate to policy issues, people/management issues, or information/marketing issues (20:24). Finally, Radosevich and Kassicieh tie the technology transfer challenges to proposed responses to perceived barriers (14:36). This approach provides laboratory directors a unique opportunity to identify their problems and view possible solutions--a first step to measuring the success of transfer actions.

Measuring Success

The literature search to this point illustrates that researchers have formulated a general understanding of the factors that can facilitate technology transfer and the hurdles that prevent successful fulfillment of these goals. The next step lies in measuring the relative success of particular strategies and transfer actions. Without this ability, a road map of successful actions cannot be developed. Measuring success provides initial feedback on the effectiveness of particular strategies. Without this input, unsuccessful

strategies may be exercised without the knowledge or reasoning behind the transfer failures. Unfortunately, assessing transfer effectiveness is complicated by confusion over the point in time a technology transfer actually occurs (3:243). Spann, Adams, and Souder support this assumption in their study containing recommendations for improving technology transfer. Three of seven summary recommendations relate to the criticality of developing appropriate measures. Routine measurement of transfer performance can help researchers focus the market applications of their technologies. The result may lead to improved technology transfer rates (19:72). A distressing fact is that nearly five percent of federal laboratories never use the most popular transfer measures (19:70).

A popular federal measurement technique is to count the number of inter-laboratory or laboratory to commercial research agreements (CRDAs). Bozeman and Crows' study, supported by the NCRDP data, conclude that the structure and quality of the agreement are much more important than the sheer number of agreements (4:243). Their research did concede that thresholds may exist for active technology transfer organizations. In general, labs with larger total budgets, and more scientific personnel, are more likely to engage in successful technology transfers (4:243). This does not translate that laboratories with larger budgets and personnel perform better. Research does indicate that certain budget and personnel thresholds do exist for consistent, frequent technology transfer.

Crutcher and Fieselman illustrate the three historic measures of transfer success (8:182). In the prelude discussion to the disclosure of success elements, the authors identify an element that makes measurement of success difficult. The authors state that "the measure of success, as is beauty, is in the eye of the beholder" (8:182). This may be the root of confusion in Government efforts to standardize technology transfer. Government efforts to standardize technology transfer mechanisms, strategies, and measurements always overlook the diverse missions of the federal laboratories. Various

federal laboratories may require measurement emphasis in different areas. In sum, the historic measurements of transfer success can fall into three categories.

First, corporations most often measure transfer costs. The bottom line prevails. Another measurement is time. Most transfer actions take several years. Time correlates to money, therefore the longer the transfer action takes to complete, the higher the cost. Finally, performance is a measurement element. Performance measures often result in cost/benefit type evaluations (8:182). The problem with these measurements is that they do not carry meaning without a historic baseline of similar transfer actions. Few companies have enough similar transfer actions to develop the necessary metrics, although the government does have enough actions to baseline. Without measurement tools, laboratory directors must look to other means to improve their methods.

Although federal efforts are still at the identification and modeling evolutionary stages, the ultimate goal is to develop a plan which incorporates a living database to evaluate technology transfer. This database can be utilized for transfer evaluation prior to significant investments. This plan, if properly implemented, can influence success rates of using organizations.

Souder, Nashar, and Padmanabhan introduce "strategy-matching" (18:9). They define "strategy-matching" as the practice of purposefully fitting transfer strategies to the nature of the technology and the user. One analytical tool they utilize is the transfer-decision checklist (18:9). The transfer decision checklist evaluates the strategic fit of the developer organization, the technology, and the recipient organization. This can be an invaluable management decision tool for both the developer and adopter organizations.

Although strategies and methods for measuring technology transfer vary significantly, consensus remains regarding the necessity of transfer measurement as a successful transfer strategy. Organizations may perceive success, as it relates to technology transfer, from varying perspectives. Some organizations perceive success

prior to the point of commercial success or economic benefit. Understandably, technology transfer provides auxiliary benefits to host and acquirer organizations. But the majority believe technology transfer really succeeds when society receives benefit. And society receives benefit when new knowledge is acquired, jobs are created, corporations profit, and consumers benefit. Accordingly, this research effort identifies successful technology transfer with commercial product sales and other benefits that stimulate the economy.

Summary

This chapter reveals that despite active legislative involvement, the act of successful technology transfer still alludes some federal facilities. Fortunately, research indicates that federal improvements are possible by addressing critical processes. For instance, research indicates that the marketing model technology transfer method produces improved rates of transfer. In addition, the literature review highlights possible successful implementation measures, but few are tailored to the varied missions of our federal laboratories. This study will utilize the successful technology transfer attributes identified by literature as a basis for analyzing characteristics present in a sample of federal to commercial technology transfer actions. The following chapter will highlight the methodology, beginning with the successful attributes identified in this chapter, through description of methods for analysis of survey results.

III. Methodology

Introduction

The object of this research is to analyze characteristics of a sample of Air Force laboratory technology transfer actions by determining the presence of successful transfer attributes in the samples. This analysis will illustrate relationships between the relative success or failure of specific transfer actions and the amount of successful transfer attributes the sample actions exhibit. This chapter will outline the analysis process beginning with identification of successful attributes, development of critical transfer process attributes, survey development, sample assimilation, sample data gathering, and data evaluation. The chapter is organized by topical discussions on research design, research sample population, instrument development, analysis, and limitations.

Background

The literature review reveals that most previous technology transfer studies can be identified by the transfer process their research emphasized. Many previous research efforts addressed one, or a combination, of three critical processes: transfer models, successful attributes, and transfer measurement. The research has not reached consensus on how to define, track, or measure the success of technology transfer (19:63). The lack of a consensus regarding fundamental theories of the technology transfer process suggests that further exploratory research is necessary. What is needed is further focused studies applying the results of previous literature. This study will utilize data from previous literature to explore the relationship between actual technology transfer actions and postulated technology transfer techniques.

Research Design

This research is exploratory in nature for several reasons. As discussed previously, technology transfer research has not reached a mature stage. Most research is less than ten years old. Cooper and Emory state that researchers need to do an exploration when the area of investigation is new or vague (7:118). Furthermore, exploratory research is appropriate when important variables are not known (7:118). An outcome of this study may pinpoint technology transfer strategies the Air Force can implement. Currently, these variables are unknown. Also, this research may predict the practicality of more formalized research designs. Cooper and Emory commend the wisdom of preliminary exploratory research prior to costly and time consuming formal research (7:118).

The first step in most research designs is the literature review. This study highlights the extent of past efforts and illuminates the direction of the current study. The literature review helps to determine if the study should be qualitative or quantitative, highly structured or less structured, involve large samples or small, and so forth (7:114). Current technology transfer literature exhibits qualities of above average coverage but is limited in depth. Studies of relative depth are limited to technology transfer trade journals and conference proceedings. Coverage of the topic spans from popular news magazines to professional management and engineering journals. The focus of this literature review is research encompassing critical processes of technology transfer: modeling, attribute identification, and measurement.

Each process area is important to overall transfer improvement. For instance, several research efforts identified the marketing model as a determinate of improved rates of transfer (3:245,5:16). Other studies emphasized the need to identify and implement successful transfer marketing techniques and other methods that have proven impact (3:252,6:27,19:71). While some studies declared that organizations developing and utilizing technology transfer measures are successful transferors of technology

(2:277,8:178,9:1,19:72). The conclusions beckon further research which synthesizes the past efforts and applies the findings to actual technology transfer actions.

The objective of this research is to use knowledge obtained from past research to evaluate the state of nature in a sample of technology transfer actions. Sauder, Nasher, and Padmanabhan identified the need for a continuation of past transfer research in "A Guide to the Best Technology-Transfer Practices." They stated that future research should study the relationships between the best technology transfer practices and the degree to which they are important to the success or failure of specific technology transfer cases (18:13). Therefore, this research will examine the relationship between Air Force laboratory technology transfer actions, and the best technology transfer practices identified in the literature review. Chapter Two summarizes the previous data and lays the foundation for an exploration of the relationships between successful attributes and their affect on specific technology transfer cases.

Research Sample Population

The population consists of technology transfer actions originating at Armstrong and Wright Laboratories. Private industry participants in the transfer samples vary. Sample acquirers range from sole proprietorships to Fortune 500 corporations. Beside the originating and acquiring organizations, the technologies also are critical to population characteristics. Technology characteristics inherent in the population vary from leading edge technologies to legacy technology transfer efforts. Specific information regarding organizations, personnel, and technologies in the sample technology transfer actions have been purposefully omitted to protect respondents, technology disclosures, and facilitate frank response to the survey questions.

Developer Organization and Personnel. All sample transfer actions emanate from either Wright or Armstrong Laboratories. The laboratories comprise many smaller

laboratories organized by research focus. It is the diversity within the laboratories that provides the gamut of technology transfer experiences among this population of transfer actions. For instance, the 15 sample transfer actions from Wright Laboratory come from four laboratory directorates: Materials, Electronics, Manufacturing Technologies, and Flight Dynamics. Within each directorate, sub-directorate laboratories address different disciplines. The largest concentration of samples (8) come from the Materials Directorate, but within the directorate, samples originate from six separate sub-directorates. Similarly, the five samples originating at Armstrong Laboratory emanate from three directorates. Diversity in the sample population was necessary in order to gather data that may reflect upon Air Force laboratory technology transfer practices in aggregate.

All the data emanates from participant interviews with key personnel on the developer and acquirer teams. Interviews at federal laboratories were with individuals intimate with the technology and the transfer project. In some cases this critical link was the inventor, or a scientist who "champions" the development effort on behalf of a lower level scientist. This research effort interviewed personnel close to the technology and project development efforts. Without these individuals, technology transfer can not be conceived -- it is not fertile. Because scientists and technologists supply inventories of technologies and facilitate initial technology transfer efforts, their perception of transfer processes is most critical. The opinions of laboratory management and administrators were not sought.

It is vital that the interviewee have adequate knowledge to answer the survey questions. In order to insure data accuracy, laboratory personnel should have been present prior to, and at the point of technology transfer conception. If the interviewee is the inventor, initial involvement was highly probable. In addition to personnel qualities, including intimacy with the technology and presence at the transfer project conception, personnel should be aware of all efforts directed towards project completion.

Introductory conversations with potential interviewees identified personnel characteristics. On several occasions, conversation with the laboratory initial point of contact led to identification of personnel more aligned with this research focus.

Acquiring Organization and Personnel. Corporations, from very small sole proprietorships to Fortune 500 corporations, comprise the acquiring organization population. Specifically, eight acquirers are very small businesses, many formulated exclusively to exploit commercial applications resulting from the technology transfer project. Although these "hungry" companies generally lack resources and marketing experience, in many instances they exhibit strong technical capabilities. Two very large corporations present in the population became involved in the transfer project due to the efforts of key personnel in their organization. The remaining ten corporations range from established small businesses to large corporations. The diversity of acquirer organizations insures a wide range of transfer viewpoints and motives.

Acquiring organization personnel characteristics are largely determined by the size of the organization. Unanimously, the company President was the interviewee for the eight very small businesses. Some of these businesses were formed solely for the purpose of exploiting commercial opportunities surrounding the technology transfer project. Consequently, corporate Presidents were intimate with the transfer development effort and most considered themselves the program manager. The two very large corporations had an individual who personally identified the transfer opportunity and lobbied for corporate support. Their efforts, instrumental to bringing the project to the company, insured their continued involvement directed towards insuring project success. The remaining sample acquiring organization personnel were either program managers or technical points of contact. In all circumstances, they are knowledgeable of the technology, project origin, and are leaders of the transfer project.

The Technology. The sample technologies do not concentrate about one scientific discipline or technology area. The most common technology concentration in the population is software. Software development and advancement was the subject of 5 transfer actions and an integral part of the development efforts of several other samples. Again, the goal was to incorporate transfer actions that collectively cover a breadth of technologies. Of the 8 samples from Wright Laboratory's Materials Directorate, 4 actions directly relate to the application of materials to new products or the creation of entirely new materials or processes. In addition to concentrations of software and materials, other sample transfer actions involve a myriad of other technologies.

Within the population, balance among transfer actions with mature and immature technologies is desirable. A population of transfer actions with a preponderance of mature, or immature, technologies may not accurately reflect the effects of technology upon the transfer actions. Many of the technologies within the sample population are mature. Even though the technologies were pre-existing, the projects were novel because of new design or unique applications. Some of the other sample transfer projects were development efforts of immature technologies. Inclusion of technology transfer samples involving both mature and immature technologies may provide unique data characteristics and opportunity for analysis.

Sample Size. Considering the breadth of the survey analysis, the sample of 19 transfer actions provides adequate data as long as care is taken in selection of appropriate personnel and balance between the sample characteristics. The breadth of analysis prevented utilization of larger sample sizes. Extensive interviews were conducted with key individuals on the developing and acquiring teams. Whenever possible, interviews were conducted personally, with phone interviews utilized for distant acquirers and developers. Personal survey administration insured consistent survey interpretation and

provided additional information beyond responses to the questions. The surveys covered all aspects of technology transfer, including management and technology related issues on the developing and acquiring teams. The exploratory effort examined each sample transfer in detail, and searching for indicators that affect successes or failure outcomes. Statistical analysis or other mathematical approaches were purposely omitted. Emphasis is upon identifying necessary and sufficient conditions for technology transfer. Large sample sizes, for the express intent of providing statisitical validity are unnecessary for this exploratory effort.

Research Instrument Development

Identification of Attributes. The foundation of this study is a baseline of successful technology transfer attributes. This list (Appendix B) was compiled from multiple research efforts which identified best methods, successful attributes, and proven marketing techniques. In all instances, successful attributes are based upon findings in previous technology transfer research efforts. Although implementation of any single characteristic may not lead to success, studies show that past successful technology transfers have exhibited some of these traits (20:26,6:24). In order to use the successful transfer list, a means of defining each attribute on the list was necessary.

Survey Formulation. A study by Fieselman and Cruther and a similar effort by Souder, Nasher, and Padmanabhan illustrate sample transfer checklists (8:5,18:9). A checklist can assist in the technology transfer decision making process or it can be used to evaluate historical transfers. For this study, surveys will be utilized to evaluate the sample of 19 past transfer actions. The survey questions are segregated by the attribute they define. The questions are also labeled to identify the responsible party the question addresses. Question responsibilities are labeled as developer (D), acquirer (A), or technology (T). A unique survey is administered to personnel in the developing and

acquiring teams. Appendix C contains the developing teams' survey while Appendix D contains the acquiring teams' survey. Some questions may relate to multiple parties and are thus labeled by multiple identifying labels. Each question is designed to best identify the extent an attribute or sub-attribute is present in the sample technology transfer action. Information to answer the survey questions are gathered from sources close to the transfer actions.

Data Analysis

Previous sections outline the method by which successful attributes are identified in the samples through the use of surveys. Answers to the surveys were obtained from personal interviews conducted with individuals close to the technology transfer actions in the developing and acquiring organizations. The next step is to analyze the survey results for each sample. Analysis indicates the degree to which successful attributes were present or absent from the sample transfers. More importantly, attribute analysis may indicate strategies for improving Air Force technology transfer strategies.

Scoring. Each survey is scored to facilitate comparison with other transfer actions. A Master Survey (Appendix E) identifies each question response as Low (L), Moderately Low (M/L), Moderate (M), High to Moderate (H/M), and High (H). A low response indicates little or no attribute presence in the transfer action while a high response indicates a high quality attribute presence.

Scores are logged on the Technology Transfer Attribute Survey Data sheet (Appendix F). A data sheet exists for developers, acquirers, and the technology. Rows on the data sheet identify samples by laboratory and sequential numbering. Columns list attributes and sub-attributes alpha-numerically. Upon completion of survey administration and scoring, the data is placed in the appropriate boxes. The spreadsheet averages each sub-attribute score, then computes average primary attribute scores. Averaged scores

appear as +/- grades (L, L+, M-, M, M+, H-, H). Developer and acquirer responses are scored separately except for responses regarding technology characteristics. The technology responses, contained on a separate spreadsheet, average the responses obtained for developer and acquirer team members.

Analysis Methods. The Technology Transfer Attribute Survey Data sheet facilitates various analysis methods. The objective is to identify and understand trends illustrated by the data sheet. Identification and analysis of the trends will pinpoint areas for improvement and further research. In order to identify all trends revealed by the data it is prudent to analyze the data from several perspectives. The first method of analysis is an all-inclusive review of the findings from each sub-attribute. This section is divided into developer and acquirer subsections. The second method of analysis will highlight trends inherent in transfer successes and probable successes. The final mode of analysis will examine characteristics of transfer failures. This analysis identifies attributes or combinations of attributes that lead to project failure. A more in-depth discussion of each method of analysis is provided in Chapter 4.

Limitations

Some methodology design limitations arise from the exploratory nature of the research design. Results can be biased by limitations arising from the development of defining questions for the key attributes. Questions were developed based upon criterion and sample checklist data available in previous literature. Also, the sample size (n=19) is not large enough to assume that the sample actions are representative of an Air Force laboratory's technology transfer processes in aggregate, although potential samples were thoroughly screened to insure a breadth of characteristics. Furthermore, sample selection was largely determined by availability of information, particularly the existence of a CRDA. Therefore, the transfer actions selected were well documented actions and some

informal transfer actions were overlooked. In defense, the existence of a formal transfer document (CRDA) does not indicate a projects' success or failure.

Summary

This chapter presented the research design, population and sample, instrument development, data analysis, and limitations. The exploratory method seeks answers to the relationships between successful technology transfer methods and actual transfer cases. Chapter four presents analysis and results from this effort.

IV. Analysis and Results

Introduction

The purpose of this chapter is to analyze information gathered from 19 technology transfer actions. The analysis evaluates the data collected against primary and sub-level technology transfer success attributes. The 19 sample transfer actions are categorized as either a success (S); probable success (PS); probable failure (PF); or failure (F). Categorization facilitates examination of the data for indicators of characteristics that enable successful technology transfer or result in transfer project failure.

This chapter begins with rationale for characterizing transfers as success, probable success, probable failure, or failure. The immaturity of some of the sample technology transfers preclude definitive "success" or "failure" classification. The "probable success" and "probable failure" classifications predict the expected outcome based upon the progress of the technology transfer at the time of this research. Later portions of the chapter describe the three analytical approaches used to evaluate the information. The first approach highlights all attributes and discusses the significance of data as it relates to each attribute. The second analysis is conducted solely on successes and probable successes. The objective of this analysis is to identify characteristics that facilitate successful technology transfer. Lastly, analysis of sample technology transfers categorized as failures indicates attributes or combinations of attributes that lead to an incomplete or unsuccessful technology transfer.

Sample Classifications

The ability to classify the 19 sample transfer actions is a critical component of the analysis effort. The data has greater meaning if the information can be extracted from a mix of technology transfers exhibiting varying characteristics. The sample population has

a mix of transfer classifications. This facilitates analysis and potential findings. For instance, a study limited to only successful transfers would inhibit findings related to characteristics of unsuccessful transfer actions. The ensuing sections will identify and define success, probable success, probable failure, and failure classifications.

Success and Probable Success Classifications. Most technology transfer researchers define success in terms of benefit to society. The purpose of federal policy, reflected in technology transfer legislation, is to stimulate federal to commercial technology transfer for the benefit of national economies and innovation rates. Therefore, "success" and "probable success" technology transfer actions require outcomes that benefit society. The most common determinate of technology transfer success is a financially successful product. That is, the acquirer firm has introduced a product to market that has its origins in the transferred technology.

Success Classifications (S). Samples classified as definite successes (S), in most cases, have developed a commercial product and sold units to federal or commercial sources. Many of the "successes" are not clear financial successes. Typically, sales volumes are low due to product and/or market immaturity. The very nature of some high technology transfer involves entry into immature markets. Furthermore, in order to ensure availability of key federal and private industry participants involved in the technology transfer project, the transfer actions evaluated in this study needed to be newly completed or still in progress. Therefore, despite current low sales volumes, products with high potential are classified as successes. Products with high potential have captive customers or the opportunity to exploit large market bases in the near future. In some cases, the goal of the technology transfer project was not a new product, but rather a product improvement. In these cases, success is determined by the degree of completion of the project, impact on the original product, and potential for increased sales and profits. In several cases, new products or product improvements are not intended for sale, but to

assist in technical services. In these cases, success is evaluated by the productive use of the product and its impact on the service market.

Probable Success Classification (PS). Probable success classification is reserved for transfer actions still in progress or recently completed, where the outcome is yet to be determined, but the prognosis is promising. At this stage, it is unreasonable to make a definitive success or failure determination. These samples are examined for indicators of probable success or failure. Indicators of probable success included development of commercial prototypes and captive customers or markets. Prototype development proves technical achievement. Captive customers and markets indicate likely sources of revenue and market share. Individuals close to the technology and product development indicated potential market impact and pinpointed hurdles necessary to achieve success.

Failure and Probable Failure Classifications. Failure transfer actions exhibit qualities inverse to success classified actions. In most cases the technology transfer project was terminated prematurely and without tangible result. In other cases, the end product or solution did not meet expectations or requirements. "Failure" and "Probable Failure" transfer actions produce little benefit to the economy.

Failure Classifications (F). All definite failure (F) transfer projects have been terminated without positive results. Most of the projects were canceled when it became apparent that the desired outcome could not be achieved. For reasons this research effort will explore, the transfer projects could not be completed as expected. In addition to project termination, projects received a failure classification if the final product or solution does not meet requirements or otherwise provide benefit to the acquiring organization.

Probable Failure Classifications (PF). None of the sample technology transfer actions fit the "probable failure" classification. The samples classified as "failures"

have been terminated and the outcome apparent. The samples classified as "probable success" all exhibit strong indicators of eventual project completion and economic benefit. A "probable failure" would be a sample transfer action that, although not yet complete, appears headed for failure or termination.

The left hand column of the Technology Transfer Attribute Survey Data table at Appendix F labels each sample as a success (S), probable success (PS), probable failure (PF), or failure (F). In addition to labeling each sample action as a success (S), probable success (PS), or failure (F), the Technology Transfer Attribute Survey Data sheet (Appendix F) compiles all the data from developer and acquirer interviews in a format conducive to comparative analysis. The next section will analyze the data sheet from three different perspectives.

Data Analysis

As described in Chapter 3, the data sheet serves as the primary tool for attribute analysis. The sheet depicts the presence of each attribute and sub-attribute in the 19 sample technology transfer actions. The sheet is organized to facilitate analysis by attribute or sub-attribute. This analysis is conducted by looking for trends within columns (sub-attributes) or groups of columns (attributes). This method of analysis is depicted first. The second section analyzes attributes of successful and probably successful transfers. Analysis of "winning" actions highlight attributes or combinations of attributes conducive to successful technology transfer. The final method of analysis will be analysis of samples classified as failures. This analysis identifies attributes or combinations of attributes that inhibit successful transfer outcomes.

Analysis of Primary Data by Attribute. This section analyzes data by attribute. Descriptions are presented by sub-attribute with summaries at the primary attribute level. Analysis by sub-attribute provides for clear delineation not attainable at the primary level.

Descriptive analysis for developers and acquirers are provided separately. Some primary attributes and sub-attributes may relate to only one party, while the majority relate to both developer and acquirer. The letters (D), (A), or (D,A) will appear next to each primary attribute and sub-attribute headings. This identifies the parties applicable to the attribute: developer (D), acquirer (A), or both (D,A). The primary and sub-attribute headings are depicted in bold print. Reference to the Technology Transfer Attribute Survey Data sheet (appendix F) and the developer and acquirer survey questions (appendix C and D) are necessary to facilitate understanding of the summary analysis.

1. High Level Commitment (to overall technology transfer policy) (D,A)

Developer:

1A: Top management abreast of technology transfer projects and involved in tracking them. Success and probable success transfers have a system for tracking technology transfer projects. The developer organization management maintains an awareness of project status through the use of meetings and/or reports. In more than half of the failures, top management also maintained an awareness of project status. The data indicates that this is a desirable trait, but one that does not guarantee success.

1B: Resources are made available to actively seek technology transfer opportunities. Three questions address the availability of personnel, funds, and facilities for technology transfer seeking activities. The findings indicate that personnel, not funding, is most important to developing organizations in regard to seeking technology transfer opportunities. Most successes and probable successes have a dedicated team or individual seeking technology transfer opportunities. Most successes (definite and probable) did not fund transfer seeking activities, while some failures did fund seeking activities. Funding of seeking activities does not appear to be an indicator of success or failure.

1C: Management has a written, formal plan for promoting technology transfer. Data overwhelmingly indicates that developing organizations do not require a formal plan for promoting technology transfer. The majority of successes and probable successes do not have a plan that is utilized on a regular basis.

Summary: The idea of an informal transfer culture supported by management emerges as conducive to successful technology transfer. The characteristics of this environment is top level management that encourages transfer activity. Data indicates that successful transfer management maintains awareness of project status and is involved in tracking them. Furthermore, organizations tend to support personnel responsible for seeking technology transfer opportunities, but funding and facilities for this purpose is secondary or non-existent. In addition, developers deny the existence of written, formal plans promoting technology transfer.

Acquirer:

1A: Top management abreast of technology transfer projects and involved in tracking them. Similar to characteristics of developers, most acquirers have a technology transfer project tracking system and top management is aware of project progress. Acquirers exhibit a wider variance in the level of top management surveillance. One acquirer program manager rated upper management project awareness low because it only wanted to know when things were going poorly. The project manager was left to devise his own transfer project tracking system.

1B: Resources are made available to actively seek technology transfer opportunities. The existence of resources for seeking technology transfer opportunities seems to indicate a higher level of support by the acquiring organization than the developing organization. Although data indicates that transfer seeking activities do not directly affect the success or failure of an on-going transfer project, the lack of transfer seeking activities, among failures, indicate technology transfer inexperience or lack of

commitment by senior management. Most of the samples describe their organization as having transfer seeking responsibilities included in the responsibilities of personnel with other primary duties. Most successes obtained funds for seeking technology transfer opportunities from organizational budgets. Conversely, failures did not fund seeking activities.

Summary: In regard to transfer project management and tracking, acquiring organizations tend to push responsibilities to lower levels. A separation exists between successes and failures related to technology transfer seeking activities. Technology transfer projects that failed did not have individuals or teams dedicated to seeking technology transfer projects while most successes exhibit this characteristic.

2. High Level Commitment (to specific transfer) (D,A)

Developer:

2A: Organization has a formal commitment to the specific technology transfer. Individuals rate the importance of technology transfer to their job higher than their organization's commitment to technology transfer. Actions by responsible individuals on the developing side seem to effect the transfer outcome more than organizational actions. All samples, both successes and failures, generally rated their personal commitment higher than their organizations'.

2B: Technology transfer project is granted adequate financial and personnel resources. Data indicate the effects of developer allocation of financial resources to transfer projects is inconclusive. Several successful transfers did not receive any financial resources from the developing organization. Other successes and some failures did receive financial resources. A typical characteristic of federal to commercial transfers, inherent in this sample of transfer actions, is limited developer funding, but strong developer personnel involvement.

Summary: Individuals rate their personal commitment to technology transfer higher than their organizations'. For developing organizations, high level commitment does not have to mean financial support or commitment to the same degree necessary of the individual developer. Management commitment, in regard to specific transfer actions, should support individual efforts to make the transfer succeed.

Acquirer:

2A: Organization has a formal commitment to the specific technology transfer. In general, successful sample actions exhibit a higher level of individual and organizational commitment than failures. No failures rate technology transfer as a highly important part of their job responsibility. Eight successes rate technology transfer highly important or moderately important. This indicates that personal commitment and project "ownership" are critical components of transfer success.

2B: Technology transfer project is granted adequate financial and personnel resources. The majority of successes have funding adequate to successfully complete the project. Conversely, failures desired additional funding to realize the project's full potential. Unlike the negligible affects of developer side funding, it appears that acquirer side funding significantly effects the transfer project outcome. In fact, developers should seek acquirer partners that have the financial capability and commitment to complete a project.

Summary: Successful transfers should have an individual or a team that is highly dedicated to the project and personally vested in the outcome. The role of the acquiring organization's top management is mostly support and its level of involvement is not the driver. On the other hand, acquirer funding is a driver of successful transfer outcomes. The lack of complete funding by failures indicates that funding to a sufficient level is conducive to successful transfer. Developers should seek acquirers with the financial capability and commitment to succeed. The level of commitment by acquiring side

management is driven but sufficiency of funds and the ability to support dedicated project managers.

3. Informal Processes (D,A)

Developer:

3A: Organization structure facilitates informal technology transfer processes. Most developers feel that their organization supports informal technology transfer processes. In fact, some successes state that the laboratory organization empowers personnel to exploit technologies. The predominant answer among failures is that organization structure does not inhibit unconventional methods to exploit potential transfers. The data indicate that proactive involvement by management to facilitate technology transfer improves the probability of transfer success.

3B: Procedures are in place for requesting funds for technology transfer projects. In most cases, procedures for requesting technology transfer project funds are non-existent or they are informally arranged. As in the conclusion of developer sub-attribute 2B, procedures for obtaining funds does not seem to be a driver for successful technology transfer. The data indicates that success can occur with or without direct funding.

3C: Technology "champion" is present. Most samples, regardless of classification, acknowledge the presence of a technology champion. The "champion", either a high level manager or someone close to the technology, promotes the transfer and ensures project completion. The existence of a "champion" does not guarantee success, but it does seem to have a beneficial effect.

Summary: Data indicate that successful developing organizations do a good job of supporting informal technology transfer processes. This support, another indicator of transfer culture discussed in developer attribute area 1, assists key developers in their

actions to ensure transfer success. Procedures for requesting funds are poorly defined in developing organizations because funds are seldom available. Regardless, data indicates that the availability of developer financial resources and the procedures to obtain funds are not critical to success. Many of the sample actions succeeded without developer funding and knowledge of funding procedures. Technology "champions" were recognized in most samples, but their presence does not guarantee success.

Acquirer:

3A: Organization structure facilitates informal technology transfer processes. Half of the successes are proactive when it comes to empowering employees to exploit technologies. Other successes typically do not hinder informal methods. This response is similar to the developing organization's response. Although, organizations that facilitate informal technology transfer processes appear to increase opportunity for success, it does not guarantee success. In support, most failures did not hinder informal methods.

3B: Procedures are in place for requesting funds for technology transfer projects. While a majority of definite successes have streamlined or written procedures for requesting funds, the data is generally inconclusive. From the analysis of attribute area 2, we know that acquirer funding is important, but the method by which funds are obtained appears inconsequential. This occurs because many acquiring organizations are small businesses where procedures are not necessary for funds requests. They merely ask the president/owner.

3D: Product "champion" is present. A product champion was present in all samples, regardless of classification.

Summary: Among acquiring organizations in successful technology transfer samples, management is mostly proactive or they do not hinder informal technology transfer processes. On the other hand, most failures do not hinder informal processes

either. Most acquiring organizations do not have established procedures for requesting transfer project funding. Many of the acquiring organizations are small businesses where procedures for requesting funds are not necessary. Product "champions" are present in every project, but they do not guarantee success.

4. Strategic Fit (D,A)

Developer and Acquirer:

4A: Both parties are in similar industries. A similar technical focus between partners seems to be important. All definite "successes" perfectly matched the acquirer in regard to technology application and personnel capabilities. Half the failures had disconnects due to mismatched technology and product applications. Data indicates that strategic fit between transfer partners is a significant influence on success. Because the federal laboratories are seldom in the same commercial industry as acquiring organizations, strategic fit arises in the similarity of technology application. Transfer partners can most effectively benefit from teamwork, cooperation, existing knowledge, tools, and facilities when the acquiring organization intends to apply the technology to a commercial application similar to the defense application.

4B: Both parties have similar personnel composition. In all but two samples, developer and acquirer personnel were of similar technical backgrounds. The two anomalies were failures in which the acquiring personnel did not have technical expertise in the subject technology. In both cases, the transfer project faced technical obstacles that the acquiring organizations could not overcome without personnel resource commitments beyond their capabilities.

Summary: Strategic fit is a critical area. Successful partners have similar goals for technology or product applications. When technology applications diverge, the positive effects of interaction between experts on the developing and acquiring teams is

undermined, diverging streams of knowledge. This finding is magnified if acquiring organization personnel do not share similar technical capability with the developing organization.

5. Location (D,A)

Developer and Acquirer:

5A: Developer and acquirer are located near one another. Other factors take precedence over distance between partners. Distance does not seem to affect success or failure. Several transfer successes overcame significant distance between facilities. Interestingly, all failing transfer actions were located within a 100 radius.

6. Funding, staffing, and facilities (D,A)

Developer:

6A: How are technology transfer projects staffed. Typically, technology transfer projects are not the development teams' sole responsibility. In fact, time away from day-to-day responsibilities may not be allocated for these activities, although successful completion is expected. This emphasizes the need for developers to be personally committed to the project.

6B: How technology transfer projects are funded. Most successes claimed their project had no formal funding. A common response among most failures and some successes was that funding was included in organization accounts. The inconclusive data supports findings obtained in attribute areas 2 and 3. In general, developer funding is not critical to transfer project success.

6F: Technology developing organization is large enough to handle all functions of research and project control including marketing products and technology. Only one definite "success" and one "probable success" claimed a well staffed transfer support organization. Most successes claimed their support staff provides some assistance, but does not include all necessary functions. A significant amount of successes (5) claimed their support organizations had less than adequate capabilities. The gamut of responses indicates that capabilities of the developing organization is not as important as the drive and commitment of individuals involved in the transfer. Success is driven by individuals, not organizations.

Summary: Technology transfer projects are usually staffed with teams, but individuals within the team are not dedicated to the project. In fact, the project is considered an additional responsibility of the team member. Success lies with the dedication of the technology "champion" to pool the expertise he/she needs. In some cases, the "champion" comprises the entire team. Many samples succeed without dedicated funding, while some failed with funding. The results indicate that funding is not a determinant of success or failure. Similarly, the capabilities of developing organizations to support transfer efforts is, in most cases, less than adequate. But inadequate support does not predicate failure. Again, success or failure is largely due to the dedication and technical capabilities of individuals close to the transfer process.

Acquirer:

6A: How technology transfer projects are staffed. In contrast to developing organizations, the majority of acquiring organizations allowed transfer project teams time to dedicate to the effort. Three of the definite successes had fully dedicated project teams. As a whole, the data is inconclusive because several successes progressed despite the lack of teams or time, while several failures had teams that were provided time to work on their project.

6B: How technology transfer projects are funded. Three of five definite successes had dedicated project funding and another drew funds from technology transfer pools of money. Some failures were funded in similar fashion. Therefore, the way transfer projects are funded does not guarantee success.

6C: Facilities are in place for developmental research and production. Regardless of classification, most acquirers rate their developmental research facilities as adequate. Three definite successes describe their production facilities as excellent. Failures consistently rate research and production facilities as adequate. In sum, transfer projects do not require exceptional facilities to succeed.

6D: Organization has, on staff, personnel experienced in the subject technology. Among the definite successes, four of five have experts or personnel adept in the technology area. No failures had expert technology, although two had personnel adept in the technology area. In sum, capable acquirer technical personnel is a facilitator of successful technology transfer.

6E: Organization has personnel experienced in development and production. The majority of successes and failures have personnel experienced in development and production. The existence of experienced personnel, although beneficial, does not predicate transfer success or failure.

Summary: The data indicate that funding, staffing, and facilities, a strong presence among definite successes, may give highly capable acquiring organizations an increased opportunity to maximize laboratory technologies. Accordingly, successes rate their research and development facilities high. Three definite successes and two probable successes report that they have "experts" in the subject technology on staff. The strongest response from failures report personnel "adept" in the technology area. In sum, the capabilities of the acquiring organization strongly influence the outcome of technology transfers.

7. Experienced technology transfer organization and strategy (D)

Developer:

7A: Closeness of the transfer agent to the developing organization. A common characteristic of definite successes was the dual purpose transfer agent/technology champion. These individuals seek partners for the technology without the assistance of transfer organizations further removed from the technology. This indicates that a technically proficient transfer agent, intimate with the developing organization, is a facilitator for successful transfer. Again, this does not guarantee success. Two failures had close transfer agents, while the other three failed using transfer agents outside the developing organization. When a technology transfer organization facilitates the partnering, similar outcomes are manifested. Most successes and all definite successes, utilized a technology transfer organization that was a part of the developing laboratory. Three transfers that were partnered by an outside organization failed. This indicates that partnerships formed by individuals or organizations intimate with the technology tend to chose better transfer partners and projects succeed more often.

7B: Organization has a formal, written process for technology transfer. The presence of a written process plan for technology transfer does not appear to increase the opportunity for success. Most successful transfer organizations do not have a written process plan.

7C: Technology transfer strategy involves the inventor in the technology transfer process. Data indicate that it is important to have inventor involvement in the technology transfer process. Most developers handle project technical and administrative duties. With one exception, failures responded equally. In only one transfer project was the inventor not intimately involved. In this case, the acquirer canceled the project after substantial investment. The acquiring organization estimated resources to successfully

develop a commercial product beyond their capabilities. More developer involvement may have prevented the tardy assessment.

7D: Inventor allowed to dedicate "corporate" time to the transfer project. In all but two successes, the inventor was encouraged to dedicate time to transfer projects. In the two remaining successes, the inventors' other job responsibilities maintained priority. On the other hand, in three of five failures inventors were allowed time only on "official" projects or no time at all. This conclusion goes hand-in-hand with previous findings showing it is necessary to provide developers with an environment conducive to successful transfer. Dedicated individuals need time to focus on the transfer project. On the developing side, the inventor has the single most influence on the transfer outcome.

7E: Organization has completed technology transfers. Most developers rate themselves experienced in technology transfer actions. Developer transfer experience is an influence, but it does not guarantee success.

Summary: Successful technology transfers tend to have transfer agents and transfer organizations within their immediate organization. In fact, many of the successful developers (i.e. inventors) cited themselves as the principal transfer agents responsible for locating the transfer partner and facilitating the transfer agreements. This seems to have a significant affect on transfer success. The agent is intimately aware of the technology and can better understand the fit of the technology with potential partners. Data indicate that external transfer agents, although valuable because they increase total transfer opportunities, may arrange partnerships that are not in the best interest of the developing or acquiring organizations. The inventor or developing organization technology "champion" is the single most important component on the developing side. This critical individual is involved in the project to the maximum extent possible in successful transfers. Furthermore, the successful developer is allowed to dedicate time freely to the project.

The goal of the developing organization is to facilitate a transfer culture conducive to inventor productivity and ultimately technology transfer project success.

8: Autonomy (D,A)

Developer:

8A: Organization has a technology transfer organization. All definite successes cite the existence of a transfer organization within the technology development laboratory. Three failures state that they rely upon transfer organizations outside the laboratory. As discussed in attribute 7, external transfer organizations may increase rates of technology transfer, but decrease rates of successful technology transfer.

8B: Level of decision making control in the technology transfer organization. Most successes state that the technology transfer organization has either complete decision making authority or the ability to make most decisions. Two of the failures that relied upon external technology transfer organizations claim that the organization had complete decision making authority. Laboratory/industry partnerships initiated without key developer consultation cause misalignment between the developer, acquirer, and the technology. Misalignment may involve project goals that do not match developer expertise, marginal developer incentive, lack of acquirer technical knowledge, inadequate acquirer production or marketing experience, or inadequate acquirer financial resources.

Summary: The data indicates that technology transfer organizations within the developing organization increase potential for successful technology transfer. External technology transfer organizations may increase occurrence of technology transfer, but outcomes may be less than satisfactory. Furthermore, negative side effects may result from externally facilitated partnerships lacking developer involvement.

Acquirer:

8A: Organization has a technology transfer organization. Most successes have their technology transfer organization at corporate headquarters or business unit management offices. Typically, the organization was embedded in the responsibilities of management personnel. Some successes and failures did not have a technology transfer organization.

8B: Level of decision making control in the technology transfer organization. The results are inconclusive. Most successes cited high levels of decision making control within the technology transfer organization. Lower ratings consisting of no authority and limited authority exist among successes and failures alike.

Summary: The results are generally inconclusive. Three successes survived without a technology transfer organization and most acquirers embedded the technology transfer organization within the duties of management personnel. The level of decision making control did not influence the transfer outcome.

9. Product development and commercialization experience (A)

Acquirer:

9A: Organization has completed technology transfers. Among successes and failures, transfer experience did not predict the outcome of the transfer. Other factors seem to drive transfer success. Likewise, the complexity of the project relative to past efforts does not drive the transfer outcome. Furthermore, acquirers that generate revenues predominately from production efforts do not hold an advantage over service-oriented acquirers.

9B: Formal process plan exists for receiving technologies. Most sample transfers do not have a process plan for receiving technologies. Four of 19 samples claimed a process plan for receiving technologies. Of the four, only one was classified a

failure. This may indicate a plan for receiving technologies is helpful, but the majority of successes prevailed without one.

9C: Business plan exists for receiving technologies. 13 of 14 successes have a business plan for commercializing the technology. Four of five failures lack a business plan. A business plan illustrates the acquiring organization's primary goal and the intermediate actions necessary to achieve the ultimate objective. A business plan focuses the effort on the desired commercial product or technological breakthrough. Lack of a business plan may explain why some failures fell behind schedule and ultimately failed.

9D: Where do technologies originate. Failures predominantly develop their own technologies internally. Successes are split equally among predominantly internal development and predominantly external development. The data is inconclusive, but it appears to indicate that chance of failure increases when transfers are attempted by acquirers who typically develop their technologies internally.

Summary: A business plan for commercializing technologies is a driver of successful transfer project outcome. Again, 13 of 14 successes developed a business plan while 4 of 5 failures neglected this activity. On the other hand, technology transfer experience is not a driver of transfer success. Additionally, production-oriented acquirers do not hold an advantage over service-oriented organizations. A process plan for receiving technologies may improve chances of success, but other factors are more critical. You can certainly succeed without a process plan. The most successful acquirers obtain technologies from both internal and external sources. Failures focus upon internal development of new technologies; making transfers more of an exception than a rule. This may indicate that experience in accepting transfers is an important factor in transfer success.

10. Entrepreneurial (D)

Developer:

10A: Marketing and advertising of technologies targeted to relevant industries. Most developers indicate that they marketed technologies to relevant, targeted industries. For years, laboratory standard practice has been to abstract technologies in publications which private industry could access if they knew how. Data indicate a shift from generic advertising to targeted efforts in successful transfers. Four of five failures either did not market technologies or they only used the same publications regardless of the technology. Successes are more progressive in regard to marketing and advertising.

10B: Technology maturation supported by internal units or by contracting out. Technology maturation is the development of technologies beyond their current state. For example, prototypes are maturation of product development efforts. In most cases, technologies developed in federal laboratories must be further developed and refined before entry into commercial markets. Among the sample transfers, some successes developed technologies beyond internal requirements for technology transfer potential and others contracted out for this service. The majority did not further develop technologies. The data indicate that success is not related to internal technology maturation activities.

10C: Cooperative agreements and incentive arrangements encouraged to facilitate technology transfer. In most cases, federal laboratories are required to utilize formal transfer agreements. Therefore, all the samples utilized a formal agreement to facilitate the transfer. In addition, most developers indicate that aspects of the transfer agreements encouraged technology transfer.

Summary: Most successful technology transfers target technology marketing and advertising efforts at relevant industries in addition to abstracting technologies for federal data bases. Although some successes and failures further mature laboratory technologies for the purpose of technology transfer, this activity does not seem to affect the transfer outcome. Developers unanimously utilize formal transfer agreements which include incentives for encouraging technology transfer.

11. Science and technology staffs (D)

Developer:

11A: Developers (scientists/technologists) participate in the technology transfer process. The data indicate that developers of successful technology transfers are formally tasked to the project or their involvement is highly encouraged by management. Management support of active developer involvement is important for facilitating a positive transfer culture within the developing organization. One failure developer described involvement as minimal; hand off the knowledge and the technology and return to other responsibilities. The individual developer in another failed transfer action could participate in the transfer project only if time from his primary responsibilities permitted.

11B: Developers have incentives to see technology commercialized. Incentives, for this purpose, are targeted toward encouraging efforts by the individual developer to transfer technologies to private industry and ensure successful commercial products result from the transfer. Both successes and failures agree that developing organizations adequately incentivize developers to see technologies commercialized. Incentives include royalties for the organization and the inventor, and awards for continued project involvement.

11C: Scientists and engineers (potential developers) are encouraged to develop commercializable technologies. Technology development incentives are targeted at encouraging individual developers (scientists and technologists) to develop new technologies with potential in federal and commercial markets. Four of five definite successes encourage developers in multiple ways. In contrast four of five failures saw limited developer encouragement. The lack of developing organization encouragement to produce technologies does not guarantee failure because several probable successes overcome a similar lack of encouragement.

11D: Active involvement in professional community. All samples indicate a high degree of encouragement, by management, for professional community involvement. Most cite technology transfer opportunities arising from professional community involvement. Professional community involvement does not appear to affect the outcome of sample transfer projects, but the interaction may increase the rate of technology transfer.

11E: The laboratory has a formal recognition process for developers and key individuals. Answers are varied for both winners and losers, but most have an established recognition process. One sample classified as a "probable success" spoke of an elaborate awards system tailored to the technology transfer development project. Unique "perks" were tied to activities that assured the continued success and progress of the technology transfer project. Two failures, beset by delays, did not have recognition programs for developers.

Summary: In sum, developers/inventors should be key players in technology transfer projects. They are individuals personally vested in the project success. Management can facilitate developer involvement by creating a positive transfer culture. Developers should be encouraged, through multiple incentives, to develop and help commercialize new technologies. Data reveals how some failures did not encourage

personnel. Like external technology transfer organizations, professional community involvement does not directly affect the outcome of transfer actions, but it can increase the rate of technology transfer. A formal recognition process appears to be a motivation tool.

12. Technology evaluation and patenting (D,A)

Developer:

12A: Organization has incentives for identification of intellectual property. Successes are evenly divided on the use of incentives for identification of intellectual property. Federal regulations specify a $100 reward for inventors of patented technologies. Some individuals considered this an incentive, while others considered this sum insignificant considering the effort involved.

12B: Organization has a dedicated support staff for the patenting process. Most developers responded that no support staff exists for the patenting process. In general, the responses were varied throughout successful and failure samples. The data indicates that patent support is not a well defined aspects of the transfer process. This is critical, considering the patenting process ensures protection of Government and corporate property rights.

12C: Outside experts allowed access in order to identify technologies attractive to industry. The data is inconclusive. Most successes responded that projects are abstracted and made available to industry through technical journals. Failures responded more favorably, claiming that industry was allowed access to laboratories to preview technologies and that technology specialists could review laboratory projects.

12D: Market research is done in-house, or by contract, on potential technology applications. As a rule, developers do not conduct market research. The single success that conducted a market research was able to partner with the industry leader in the subject technology. In this case, it appears that market research paid off.

12E: Inventors requested to identify potential markets and interested firms. Inventors are not a routine participant in the process of identifying markets and interested firms. The most common answer was that inventors input was "sometimes" requested. The spread of answers may be attributed to the haphazard way that most transfer partnerships occur. The process is typically informal.

Summary: Most scientists and developers interviewed did not consider the federally regulated $100 reward for patented inventions an incentive. Data indicate that laboratories incentivize developers in other ways. The level of patent support varies widely between laboratories. The spread of replies was surprising considering the impact of the patenting process upon Government rights and royalties. The status quo is to abstract technologies for industry review. More proactive policies are not in widespread use. Market research is a critical function that identifies the impact of the technology in markets and who the major corporations are in the markets. This activity is not conducted by federal laboratories. The one successful sample that conducted a thorough market research identified and paired with a dominant corporation in the target commercial market. Inventors are not a routine participant in the market and corporate identification process.

Acquirers:

12D: Market research is done in-house, or by contract, on potential technology applications. Most successes conduct an informal, in-house market research to identify potential opportunities for technologies. Two definite successes conduct formal market analysis. Among successes and failures alike, the acquiring organization assumes responsibility for commercializing the technology. The benefits of developer market research could be increased awareness of other related research efforts and optimum transfer partner selection.

Summary: Informal market research is a regular activity of acquiring organizations. Data indicates that market research does not guarantee success.

13. Qualities of commercial adaptability (T)

Technology:

13A: Tangible value -- new technology, when compared side-by-side with status quo provides noticeable improvement. All transfer actions rate the technology as having high tangible value. Developers and acquirers indicate that all the technologies, if produced and marketed successfully, could improve upon existing products, processes, or services.

13B: Divisibility -- technology can be brought to the market in smaller, less dramatic, less risky forms. Many successful actions do not have a product with divisible qualities. Data does not indicate a correlation between product divisibility and transfer success.

13C: Diverse market applications. Most developers and acquirers claim highly diverse market applications for their technologies. Most claim that the technology has multiple applications in several diverse markets. Because all samples scored equally high, it is difficult to ascertain benefit from this data.

13D: Exclusive property rights (patents) obtained or obtainable. Failures tend to have less proprietary coverage than successes. Property rights have a significant effect on acquirer ability to obtain private sources of funding.

13E: Ability to improve proprietary coverage is possible. The ability to improve proprietary coverage is an incentive left for the acquirers. In most cases, when a technology is developed in a federal laboratory, product improvement patents are attainable.

Summary: The qualities inherent in the technologies can have significant effect upon the transfer. Most of the samples (successes and failures) rate their technologies highly suitable for commercialization. The data addressing commercial adaptability of technologies is inconclusive. The characteristics of the technology do play a vital role in the technology transfer process. The critical attribute is the union between the characteristics of the technology and the capabilities of the acquiring organization. This union is referred to as strategic fit.

14. Strategic Fit (technology - acquirer) (A)

Acquirer:

14A: The technology is presented at a time when the organization can commit resources. The ability of the acquiring organization to commit resources does not appear to affect the success of the project as much as other factors. In effect, other factors such as the technology itself and the capabilities of the partner and its personnel are more critical than the effect of limited resources and timing. In support, four of five failures claim that the technology transfer opportunity matched a current, existing need and resources were available, but the projects failed anyway. Other factors have more effect.

14B: The technology matches the technological capabilities of one of its operating units and one of its principal markets. The majority of successes claimed that the technology fit perfectly into a strategic objective or current project. Two failures were attempting to use the technology to explore totally new business/market opportunities. The data indicates that success is more likely when the technology matches current business objectives. Success is less likely when corporate expertise is not directly related to the technology or market opportunities lie outside the firm's existing target markets.

14C: Personnel have the capability to understand, maintain, and further develop the technology on their own. Several successes prevailed without having "experts" in the technological field, but successful acquirers did possess some knowledge of the technology. Likewise, having "experts" did not prevent some sample actions from failing. The data is inconclusive.

Summary: Acquiring organizations can overcome the effects of less than optimal transfer project resources. In order to overcome the negative effects, capabilities should be strong in other areas. Some failures were unable to overcome the effects of limited financial capacity. Technology transfer projects that fit perfectly into existing business objectives hold a distinct advantage. The chance for success when the technology is used to explore other markets and stretch personnel capabilities is less likely. Four successes prevail despite a lack of an intimate knowledge of the technology. Some strong organizations can overcome limitations in technical expertise with ample financial resources, superb facilities, and personnel knowledgeable in related fields. If the acquiring organization is strong in other attribute categories, it can overcome less than optimal technical capability.

15. Life-cycle interaction

Developer:

15A: Interface is maintained between organizations. Most successful developers conduct scheduled, periodic meetings with the transfer partner. This interaction facilitates communication between partners and adherence to project milestones. In most cases, the inventor or another individual close to the technology communicates with the acquirer during the interface meetings.

15B: Incentives provided to the developing organization personnel are structured to encourage cooperation after initial commercial development and throughout the product life-cycle. Most developers cite incentives directed towards encouraging life-cycle involvement. In most cases, this provides an opportunity to receive royalties tied to sales of the commercial product. This trait is present in both success and failure cases.

15C: Acquirer sought input from the developer during cost and schedule estimate formulation. Developer input for cost and schedule purposes was not sought on many successful transfers. Likewise, in three of five failures developers were not involved. The results are inconclusive.

15D: Both parties perceive organizational benefit from commercial product development. Four of five definite "success" developers claim benefit for their organization at the point of technology transfer. Despite this belief, the projects resulted in commercial success in every case. Evidently, organization perceive "benefit" differently than the desired outcome of the transfer project (commercial success). Many organization perceive benefit prior to the point of product commercial success. Among the failures, a majority replied that benefit occurs at the point of product/process development. The data does not support the sub-attribute belief that developing organizations should perceive benefit when the product becomes a successful commercial product.

15E: Organizations share personnel during the transfer and development process. The data strongly indicate that sharing personnel is strongly linked to success. Four of five failures did not share personnel during the technology transfer project. 11 of 14 successes shared personnel. This also relates to the ability to convey and understand details of the project. The analysis of failures section will discuss how a lack of communication and sharing appear to strongly contribute to the negative outcome of some projects.

15F: Early involvement between developer and acquirer. With few exceptions, all samples claim to have discussed technical aspects of the transfer prior to formalizing the transfer action. This ensures that partners understand the objectives of the project prior to initiation. One sample failure did not discuss technical aspects of the transfer until after the agreement was signed. This may explain why the acquirer's specifications, when developed by the laboratory, did not meet performance requirements.

Summary: Scheduled, periodic interface meeting are preferred by successful transfer partners. Failures relied upon less frequent meetings and one did not meet at all. Universally, sample transfers cited some type of incentives to encourage developer cooperation throughout a technology and product life-cycle. Technology transfer literature indicates that involvement of the developer in cost and schedule formulation increases the liklihood of success. Most successes involved the developer, while some did not. Three of five failures did not seek input from the developing organization. The single most critical finding within the life-cycle interaction attribute is sharing of personnel during the transfer and development process. All definite "successes" worked together to accomplish transfer objectives. Four of five failures did not share personnel during the transfer effort. This supports the need to share concepts, communicate, and understand the integration of roles between the transfer partners *throughout* the project. Projects that do not share personnel are likely to fail. Finally, early involvement of transfer partners is accomplished by most sample transfer actions.

Acquirer:

15A: Interface is maintained between organizations. Successes tend to favor a long-term, steady commitment to the project. Six of eleven successes had scheduled interface meetings while failures met on an "as needed" basis or not at all. Acquirers tended to leave these meetings to the project manager.

15C: Acquirer sought input from the developer during cost and schedule estimate formulation. Success and failure acquirers perceive developer involvement in cost and schedule formulation higher than their developing team counterparts. Developers may have contributed without knowing by addressing technical concerns. Most acquiring successes and failures claim developer input or integral involvement related to cost and schedule estimate formulation.

15D: Both parties perceive organizational benefit from commercial product development. With few exceptions, acquirers identify benefit of transfer projects when the technology leads to a financially successful product. Acquiring organizations exist only if they make a profit and most acquirers were keenly aware of the profit motive behind technology transfer.

15E: Organizations share personnel during the transfer and development process. In line with the developers response, sharing leads to success, while a lack of sharing increases the chance of failure. All acquiring failures did not share personnel, while all definite successes did share. Sharing increases informal communication, increases project status, and the amount of knowledge transfusion.

15F: Early involvement between developer and acquirer. The results are inconclusive because all failures exchanged information prior to the point of transfer while some successes prevailed without prior involvement between partners.

Summary: As was indicated in the developer analysis, sharing personnel during the transfer development process is a characteristic of successful transfers not present in the majority of failures. Successes also utilize scheduled meetings to ensure program success. Acquirers perceive developer involvement in cost and schedule formulation higher than developers. Although data is inconclusive, developer involvement in cost and schedule formulation can provide added validity to project estimates. Acquirers perceive benefit from technology transfer projects when the subsequent product or process returns

profit to the organization. Only one sample, a probable success, indicated benefit at the point of technology transfer.

This section analyzes data attribute by attribute. Each attribute is reviewed and the data summarized. The next section reviews the data from the perspective of success (S) and probable success (PS) technology transfer samples. Only definitive findings will be discussed.

Analysis of Success (S) and Probable Success (PS) Technology Transfer Samples. This section analyzes the characteristics inherent in samples classified as a "success" or "probable success". This section and the following section on failures will not address all attributes, only the attributes that appear to influence the success or failure of technology transfer. The analysis is organized by developer and acquirer. All the key attributes associated with successful developers will be highlighted followed by all the key attributes of successful acquirers.

Successful Developers

1. High Level Commitment (to overall technology transfer policy)

1A: Top management is abreast of technology transfer projects and involved in tracking them. The data indicates that most successful developers have a management team that actively tracks and monitors transfer projects. Management commitment to a project can instill confidence in the developing team. Also, tracking ensures that valuable resources are directed towards efforts with high probabilities of success. The ability of high level management to breed a transfer culture leads to inspired action by developers with vested interest in the project. Therefore, the benefits of proactive high level project awareness is twofold. First, management can ensure the project is progressing

satisfactorily. Second, management participation facilitates individual developer belief that the project is important to the organization.

6. Funding, Staffing, and Facilities

Low developer scores indicate that resource inadequacies in the developing organization can be overcome by dedicated individuals on the developer and acquirer sides. In particular, developer funding and dedicated staffing are two sub-attributes not critical to overall transfer project success. But one success and one probable success competed for funding with the Advanced Research Project Agency's (ARPA) Technology Reinvestment Project (TRP). This program strives to maximize commercial opportunities for federally developed technologies. Private industry views ARPA's selective collection of federal technologies as the best federal laboratories offer. The TRP process selects the most capable federal and private organizations and guarantees equal funding from both parties. ARPA's involvement ensures adequate financial commitment to complete the project. With the exception of programs such as ARPA TRP, developer success is driven by committed individuals, not high levels of funding or staffing.

7. Experienced technology transfer organization and strategy

7A: Closeness of the transfer agent to the developing organization.

Successful developers overwhelmingly responded that the transfer agent is a part of the developing organization. In many cases, the developer is the transfer agent. Transfer agents close to the developing organization usually hold an intimate knowledge of laboratory technologies. These agents are best able to protect the interests of the laboratory while presenting laboratory capabilities to industry. A transfer agent close to the developing organization appears to be a successful formula. This agent pushes the technologies to interested parties. The technology transfer agent is highly versed in the lab technology and sets out to find industry partners. The key factor is that the person facilitating the transfer should have technical expertise in the transferred technology.

8. Autonomy

All definite successes have a technology transfer organization located within the laboratory and the organization has authority to make most decisions regarding the technology transfer project. The ability to make decisions, coupled with high ratings of personal commitment to the project indicates that "champions" certainly effect the outcome of projects. High level management support also encourages developers to succeed. Management's position should be to provide an environment of centralized support, but allow their technologists the ability to execute the transfer (decentralized execution).

11. Science and technology staffs

11A: Developers participate in the technology transfer process. Most successful developers indicate that participation in transfer projects is a job responsibility and highly encouraged by high level management. Again, data reveal that management's role is to institute a positive transfer culture, while developers are required to make the project a success.

11C: Scientists and engineers (potential developers) are encouraged to develop commercializable technologies. Many successful developers indicate that their organization provides incentive programs to encourage inventors to develop commercializable new technologies. The unique characteristic of successful programs is that multiple incentives are utilized.

15. Life-cycle Interaction

15E: Organizations share personnel during the transfer and development process. Data clearly indicate that successful transfers share personnel, while failures tend not to share personnel. Teaming between partners facilitates informal channels of communication and better technical understanding. The ability to assess one's priorities

and better understand the magnitude of the effort early in the project life-cycle can save valuable time and money; especially when it appears goals can not be met.

Successful Acquirers

1. High Level Commitment (to overall technology transfer policy)

1A: Top management is abreast of technology transfer projects and involved in tracking them. In most samples, acquirer management tracks transfer projects and maintains awareness of program progress. Some low scores were characterized by a management structure where the program manager has complete authority. Upper management awareness and active involvement is a factor exhibited in most successful samples.

2. High Level Commitment (to specific transfer)

Successes cite a high level of personal and organizational commitment to technology transfer. Adequate funding is critical to transfer success. Most successes respond that projects are funded "enough to do the job well". Conversely, no failures indicate funding to this level of satisfaction. Acquirer commitment is critical to success.

3. Informal Processes

Acquiring organizations score high in promoting or not inhibiting informal ways to exploit transfer activities. This attribute, conducive to a positive transfer environment, empowers personnel to seek new transfers and accomplish existing transfer projects. Four of five definite successes have procedures for seeking funds. Some small company acquirers state that fund requests were handled informally. All successes have a product "champion".

6. Funding, Staffing, and Facilities

Among definite successes, funding and staffing are usually dedicated to the project. Evidently, these projects are identified as worthy of adequate personnel and funding levels. Most successes claim their organization has personnel experienced in both product development and production. Additionally, personnel are most often experts or highly adept in the subject technology. In the case of ARPA TRP projects, acquiring organizations are competitively selected as the most capable and most likely to succeed with the technology. Some under-funded projects appear to compensate for this disadvantage with highly capable technical and production facilities.

9. Product development and commercialization experience

A vital ingredient for success is an acquirer business plan for commercializing the technology. All successes, excluding one, have a business plan for commercializing the technology. The one probable success that does not have a business plan successfully developed a commercial product, but is experiencing difficulties selling the product. All failures, excluding one, do not have a business plan.

14. Strategic fit

For most successes, the technology is a strategic fit with existing business units, financial resources, and personnel. Successful transfers usually involve technologies related to existing acquirer products. The ability for the acquiring organization personnel to work with the technology, understand it, and further develop it, is critical. The application of the technology should be in similar markets as well.

15. Life-cycle interaction

Consistent with the developer data, sharing is a critical component of successful transfers. It appears that partners that work together stand a better chance of success. Some successes prevail without sharing, but some of those projects are not conducive to a shared effort. In two cases, the laboratory used their expertise and special equipment to

provide recommendations for improving existing commercial products. A valuable transfer effort for the acquirer, but not a project conducive to a shared effort.

This section highlights attributes prevalent in success and probable success technology transfers. The next section will analyze failures, case by case, for indicators leading to unsuccessful technology transfer.

Analysis of Technology Transfer Samples Classified as Failures. Because of the limited number of samples classified as failures, each sample can be analyzed independently, enabling a better understanding of the failure characteristics. The analysis of samples are sub-divided into developer and acquirer sections. The objective is to identify attributes, sub-attributes, or collections of attributes that cause failure in technology transfer projects.

Failure 1 (F1-WL5)

Developer

12D-E: Market research is done in-house, or by contract, on potential technology applications and **Inventors requested to identify potential markets and interested firms.** The lack of market research, common to all samples, does not determine success or failure. However, when coupled with the exclusion of the inventor in the identification of potential markets and interested firms, the inability to select adequate industry partners significantly increases. In this case, an external technology transfer organization matched the acquirer with the laboratory. Inadequate pairings, arranged by an "outsider", undermine a critical component of successful actions: technology champion dedication. The lack of involvement in the selection process may erode the "champion's" dedication and faith in the project.

7A: Closeness of the transfer agent to the developing organization. As mentioned above, an external transfer agent facilitated the partnership. Externally initiated technology transfers have some advantages as well as disadvantages. Namely, without an external organization "pulling" technologies from the laboratory, some technologies may never be exploited and never have the opportunity to benefit society. Some Federal laboratories do not publicize, market, or advertise technologies, and thus require external transfer agents. Unfortunately, in some cases, external transfer organizations do not optimize pairings. They often select corporations with less than adequate capabilities. Federal technology transfer projects with inferior partners can tie up valuable federal research personnel and funds. This approach does not optimize federal investments in research and development.

15E: Organizations share personnel during the transfer and development process. The acquirer could have benefited by exposing some of their personnel to laboratory experts. Teamwork facilitates communication and mutual understanding. Transfer projects, such as this one, that do not share personnel risk failure as a result of poor communication. In this case, teamwork may have enabled personnel to discover alternative routes around technological barriers that ultimately caused project failure.

Acquirer

1. High Level Commitment (to overall technology transfer policy). The President of the company only expresses moderate commitment to technology transfer. Although no formal system for tracking projects exists, he personally keeps track of program progress. A similar response was given regarding personnel involved in seeking technology transfer activities. The President also handles transfer seeking activities. Technology transfer is not considered a priority nor as a means to meet future business objectives. This project was a unique opportunity that did not come to fruition.

6. Funding, Staffing, and Facilities. Due to the small size of the company technology transfer projects are funded informally. Furthermore, the acquiring organization relies completely upon the development research facilities of the developing organization. The acquirer has no development research facilities. Likewise, personnel lack product development experience. The acquiring organization's ability to advance the technology to a commercializable product appears to be severely limited.

9B-C. Process plan exists for receiving technologies.

Business plan exists for commercializing technology. Previous analysis illustrates that typical acquirer responsibilities are process and business plan development. In this transfer action, neither a process plan nor business plan are developed. Business plan conception, by the acquirer, is a necessary activity for technology transfer success.

15. Life-cycle interaction. The acquirer reports dismal life-cycle interaction. Before project cancellation, interface meetings were not planned and not regularly conducted. In addition, team members did not work together on project objectives or otherwise share personnel. Sharing personnel is a characteristic of all definite successes. On the other hand, all failures do not share personnel.

Summary: Key developer inadequacies surround the inability to communicate effectively. First, individual developers are not involved in the identification of potential markets and interested firms for their technology. Furthermore, an external technology transfer agent facilitated the transfer project. At the time of transfer initiation, details concerning technical aspects required to work with the technology were not communicated to the acquirer. After project conception, personnel did not work together -- missing another opportunity to communicate technical requirements to the acquirer.

Top level management on the acquirer side does not embrace technology transfer policies nor relay concerns to the project team. In this case, the acquiring organization

lacks adequate facilities and personnel to work with the subject technology. Furthermore, acquirer ability to influence project objectives is minimal because developing organization personnel are the only individuals capable of working with the technology. Additionally, the acquiring organization does not develop cost estimates or a business plan. They do not encourage interaction between team members or schedule meetings. Many factors affect the unsuccessful outcome. The primary "show-stoppers", summarized at Table 4-1, are: 1) Poor communication and an external transfer agent, 2) No sharing of project personnel, 3) Lack of acquirer technical capability, 4) No interface meetings during the project life-cycle.

Table 4-1. Failure 1 (F1) "Show-stoppers"

1. Transfer facilitated by an external transfer organization
2. Transfer partner personnel did not work together
3. Acquirer lacks adequate technical capability
4. Transfer partners did not interface during the project life-cycle

Failure 2 (F2-WL6)

Developer

1. High Level Commitment (to overall technology transfer policy). High level management is not an integral part of this transfer effort. The developer states that management neither has a system for tracking project progress nor is informed on project status. As discussed in the analysis of winners, high level support resulting in a corporate transfer culture is highly conducive to successful transfer. A transfer culture facilitates an environment where individuals committed to the project can excel. Without support from high level management, personal commitment to projects can be frustrating. The

developer indicates that an individual in the organization may have responsibility for seeking technology transfer opportunities, but he doubted there was funding for that activity. When asked if management had a written, formal plan for promoting technology transfer, he was unsure whether a plan existed. Regardless, it is obvious that there is little management-developer interaction regarding technology transfer activities.

7B: Organization has a formal, written process for technology transfer. The developer is unaware of management programs, although he is a high level scientist actively involved in technology transfer projects. Similar to the responses in attribute area 1, the developer states that he was unaware of a written process plan for technology transfer. At this point, management has not tracked, maintained awareness, or made personnel aware of a process plan for technology transfer. This is a sharp contrast to many successes where management successfully instilled a positive transfer environment.

12D: Market research is done in-house, or by contract, on potential technology applications. Common to both successful and unsuccessful transfer samples is a lack of market research by developers. Similarly, this failure did not conduct market research. Data indicate that transfers can succeed dispite market research, but this activity may help prevent some failures. Market research can facilitate industry partnerships with the most capable firms in the industry. The status quo is to partner with the first corporation that expresses interest. Transfer projects with industry leaders will improve opportunities for commercial success, increase exposure for the laboratory, and increase potential for revenue.

<u>Acquirer</u>

4B: Both parties have similar personnel compositions. In this action, personnel characteristics between the developer and acquirer are dissimilar. The acquirer is a production oriented supplier of common materials. The technology transfer project involves a sophisticated processing method for a unique material. The acquirer does not

have personnel experienced in the process or the materials. In particular, the processing is beyond the capabilities of the acquirer. The developer indicates that failure may have been the result of the acquirer "swinging for the fences" though they did not have "home run power" in the new technology.

9B-C: Process plan exists for receiving technologies.

Business plan exists for commercializing technology.

Corporations may be able to counteract a lack of technical expertise with a sound business plan that addresses weaknesses. But in this case, the acquirer is technically ill-prepared and lacks a business plan. This combination may be an ingredient for failure. Furthermore, a sound process plan for receiving technologies can highlight acquirer deficiencies such as insufficient technical capability.

Summary: In sum, developer top management lack of awareness and involvement contradicts the norm shared by successful transfers. Developer management has not instilled a positive transfer culture. The acquiring organization's lack of technical expertise, and product development and commercialization experience are two significant areas that, combined with developer inadequacies, significantly impact project failure. The major influences leading to transfer failure, summarized at Table 4-2, are: 1) No developer top management influenced transfer culture, 2) Inadequate acquirer technical capability, 3) No business plan for commercializing the technology.

Table 4-2. Failure 2 (F2) "Show-stoppers"

1. Developer management did not facilitate a positive transfer culture
2. Acquirer lacks adequate technical capability
3. Acquiring did not develop a business plan for bringing the technology to market

Failure 3 (F3-WL7)

Developer/Acquirer

15C: Acquirer sought input from the developer during cost and schedule estimate formulation. There is inconsistency between developer and acquirer responses to sub-attribute 15C. The developer claims no involvement in cost and schedule formulation while the acquirer says input from the developer was sought. Apparently, the developer did not consider her role influential. Regardless, neither answer contains the strong language "integral part of cost and schedule estimation." Nearly half (6) of the successful developers claim they are an integral part of the cost and schedule estimate process.

15E: Organizations share personnel during the transfer and development process. The lack of sharing may be the reason this project survives for an extended period before its inevitable failure. Well into the project life-cycle, the acquirer realizes it does not have the capital necessary to produce a commercial product. More up-front sharing of information may have shortened the time to cancellation or halted the project before initiation.

7C: Technology transfer strategy involves the inventor in the technology transfer process. This is the only transfer project where the developer does not play a key role. The teams did not interact, share, or have a developer technology champion. Technology transfer is seldom the top priority of federal or commercial organizations. Therefore, technology transfer projects need technology champions to promote the project and push it through bureaucratic obstacles.

Summary: This failure is a classic case of inadequate communication. Although this transfer scored well in many areas and deficient in only three areas, the deficiencies are "show-stoppers". The lack of interaction, exemplified by no sharing of personnel and involvement in cost and schedule estimates, is compounded by a developing team without

a technology champion. In sum, poor communication and no developer technology champion are weaknesses difficult to overcome. The "show-stoppers" are summarized at Table 4-3.

Table 4-3. Failure 3 (F3) "Show-stoppers"

1. Transfer partners did not share personnel during the transfer effort
2. Acquirer did not seek developer input during cost and schedule formulation
3. Developing organization did not allow involvement by the technology champion

Failure 4 (F4-WL10)

Developer

7A: Closeness of the transfer agent to the developing organization. This is an externally facilitated technology transfer. A transfer agent close to the developing organization is not present in this technology transfer. The acquirer sought a product improvement and the laboratory agreed to produce the improved feature. This is a classic example of technology transfer where industry takes advantage of superior federal research facilities and talent.

Acquirer

1: High level commitment (to overall technology transfer policy). The high level manager indicates he did not closely follow the transfer project progress. He expects his program manager to inform him of any delays or significant accomplishments. In this case, the high level manager was not informed of extensive delays. His apparent lack of interest may have resulted in the project receiving low priority among his personnel and laboratory personnel.

6: Funding, Staffing, and Facilities. Low funding question ratings are due, in part, to the small size of the acquiring organization. "No formal funding" was the most common response from small businesses, although projects received funding. In response to question 6D1, the acquirer does not have personnel experienced in the subject technology. This is why they partner with the laboratory. The acquirer is also weak in development and production personnel. Inadequacies in this area are insignificant with the exception of a lack of personnel experienced in the subject technology. The lack of technical expertise prevents the acquirer from ascertaining the significance of developer delays. The acquirers are forced, due to their inexperience, to trust federal laboratory personnel to accomplish the project in accordance with the agreement.

9: Product development and commercialization experience. The acquirer has little technology transfer experience. This was one of their first experiences because most of their technologies originate internally. They did not develop a business plan. See earlier discussions on business plans and their impact on transfer outcomes.

12: Technology evaluation and patenting. The acquirer is the only sample transfer action that did not conduct market research on potential technology opportunities. In simplistic terms, the acquirer exclaims that his efforts are based upon product desires expressed by his customers. In effect, this is a form of informal market analysis.

Summary: Strong developer responses are undermined by an external transfer agent. This deficit can be overcome if the acquirer is highly capable. In this case, acquirer management does not monitor transfer project progress. The acquiring organization lacks personnel skilled in the technology application. This is the acquirer's reason for approaching the laboratory -- to gain access to skilled laboratory personnel. The acquiring organization in this case has severe deficiencies in personnel and facilities and lacks technology transfer experience. Furthermore, the acquirer was the only organization not to conduct market research on potential technology opportunities. In sum, the primary

"show-stoppers", summarized at Table 4-4, are: 1) External transfer agent; 2) No acquirer monitoring progress; 3) Lack of acquirer technical capability; 4) Potential markets not identified by the acquirer.

Table 4-4. Failure 4 (F4) "Show-stoppers"

1. External transfer agent "facilitated" transfer partnership
2. Acquirer organization did not monitor project progress
3. Acquirer lacked technical capability
4. Acquirer did not perform a market analysis and identify potential markets

Failure 5 (F5-WL12)

Developer

1: High level commitment (to overall technology transfer policy). The developer is unaware of any management initiative to track or be aware of his project. He said the system established for tracking transfer project progress was not regularly used and management meetings regarding project progress were infrequent. He is unaware of any laboratory personnel involved in seeking technology transfer. He is also unaware of laboratory plans promoting technology transfers. High level commitment to technology transfer seems non-existent.

2A: Organization has a formal commitment to the specific technology transfer. The developer claims he desired more involvement in technology transfer, but it is not an important part of his current job responsibilities. He said his organization is only somewhat committed to technology transfer. This data and the data from attribute 1 supports a lack of management commitment to technology transfer policies and specific technology transfer projects.

7A: Closeness of the transfer agent to the developing organization. This partnership was facilitated by an external technology transfer organization. The acquirer sought lab expertise to improve an existing product. See previous discussions on the effects of external technology transfer organizations.

10: Entrepreneurial. This attribute indicates lack of organizational involvement in technology transfer. The developer states that his organization does not market laboratory technologies whatsoever. In addition, the laboratory does not mature technologies beyond internal requirements. This means that the laboratory is not proactive in seeking opportunities for technology transfer.

12: Market research is done in-house, or by contract, on potential technology applications and **Inventors requested to identify potential markets and interested firms.** In line with other sample transfers, market research is left for the acquirer. In this case, like some of the other failures, the inventor was not asked to identify potential markets or interested firms. The partnership was facilitated by an external transfer organization.

Acquirer

1B: Resources are made available to actively seek technology transfer opportunities. The acquirer states that his organization does not seek technology transfer opportunities. Inexperience may explain the difficulties encountered in this project and its subsequent failure.

2: High level commitment (to specific transfer). In line with the response in sub-attribute 1B, the acquirer rates his personal and organization commitment to technology transfer in the "somewhat committed" category. Technology transfer is not a priority at this organization.

3: Informal processes. Technology transfer is not a regular method to accomplish business objectives at this company. The organization does not facilitate

technology transfer. Although this project was the first technology transfer project, the acquirer says procedures for requesting funds are accomplished informally in his small company.

9: Product development and commercialization experience. The acquirer does not have a business plan for commercializing the product. Also, they do not have a plan for receiving technologies. They internally develop most of their technologies. This is a case of a small, informally managed company attempting to utilize federal resources to improve a product.

Summary: The individual developer claims top management efforts to support technology transfer are non-existent. Tracking systems were not regularly used, meetings were infrequent, and personnel were not dedicated to seeking technology transfer opportunities. The developing organization revealed little commitment to this technology transfer project. In addition to the lack of management involvement, the transfer was facilitated by an external agent. The developing organization is not proactive in seeking opportunities for technology transfer.

Similar to development team management, acquirer management does not recognize technology transfer as a corporate priority. The technology transfer project was the acquirer's first. Like other failures, the acquirer did not produce a business plan for commercializing the technology. The primary "show-stoppers", summarized at Table 4-5, are: 1) No developer management efforts to support transfer culture, 2) External transfer agent and developer efforts to seek transfer opportunities , 3) Lack of priority treatment of project from acquirer management, 4) No business plan.

Table 4-5. Failure 5 (F5) "Show-stoppers"

1. No developer management efforts to support positive transfer culture.
2. External transfer agent facilitated transfer partnership.
3. Acquirer management did not treat transfer project with priority.
4. Acquirer did not develop a business plan for bringing the technology to market.

Summary Results

The responses from uniquely qualified individuals on the technology transfer project developing and acquiring teams provide significant findings. This section highlights significant findings disclosed by all three analysis methods performed in this chapter. Key findings are organized within subsections titled "developer findings", "acquiring findings" and "findings applicable to developers and acquirers".

Developer Findings

Table 4-6 summarizes primary developer findings. Below the table, each primary finding is discussed.

Table 4-6. Summary Developer Findings

Sub-Attribute	*Attribute Description*
1A	Top management abreast of technology transfer projects and involved in tracking them
6A-B	How technology transfer projects are staffed and fundedand funded
7A	Closeness of the transfer agent to the developing organization
7C	Technology transfer strategy involves the inventor in the technology transfer process
7D	Inventor allowed to dedicate "corporate" time to the transfer project
8A	Organization has a technology transfer organization
8B	Level of decision making control in the technology transfer organization
10A	Marketing and advertising of technologies targeted to relevant industries
11C	Scientists and engineers (potential developers) are encouraged to develop commercializable technologies

1A: Top management abreast of technology transfer projects and involved in tracking them. Upper management vigilance regarding awareness of project status via tracking systems and meetings is a characteristic exhibited by successful transfer projects. In transfers that failed, top management neither tracked or supported technology transfer efforts. Top management promotes a positive transfer culture by ensuring satisfactory

transfer project progress, and instilling project importance upon the individual developer. Failure transfer 2 (F2) provides an environment where developer management involvement was non-existent. The lack of a positive transfer culture undermines the efforts of individual developers.

6A-B: How technology transfer projects are staffed and funded. Developer project funding and staffing inadequacies can be overcome by dedicated individual developers and capable acquiring partners. Many successful transfers lack adequate resources, including staff, time, and funds. As long as the technology champion has time to dedicate to the project success can still be achieved. One definite success, despite poor management support, funding, and staffing achieved success through "champion" perseverance, a promising technology, and a highly capable acquirer.

7A: Closeness of the transfer agent to the developing organization. A technically proficient transfer agent is a determinant of successful technology transfer. Among most "definite success" transfers the technology champion was also the transfer agent. Three "failure" transfers were facilitated by transfer agents that were not a part of the developing organization. It appears that some failures may be attributed to misunderstandings present at project commencement. Technology transfers facilitated by the individual developer, or someone within the developing organization, ensure superior understanding between the transfer partners.

7C: Technology transfer strategy involves the inventor in the technology transfer process. The inventor is an integral part of all technology transfers sampled, excluding one. In a failed transfer action, the inventor was excluded from the process. The project was eventually canceled when the resources estimated to bring the product to market were evaluated as beyond the acquirer's capability. The technology champion may be the only individual developer capable of articulating pertinent technical information to the acquirer.

The inventor or technology champion is the one individual instrumental to insuring transfer success.

7D: Inventor allowed to dedicate "corporate" time to the transfer project. The key individual (inventor, developer, or technology champion) mentioned in 7C must be granted adequate time to dedicate to the transfer project. This individual is a critical component of successful transfers. Withholding the exception mentioned above, all technology transfer sample key participants have time to dedicate to the technology transfer effort.

8A: Organization has a technology transfer organization. The presence of a technology transfer organization within the developing unit is a characteristic of successful developers. In fact, all definite successes have a technology transfer organization within the developing organization. The close proximity of the technology transfer organization ensures technology transfer personnel are familiar with the technologies available and their capabilities. Developing organizations without internal technology transfer personnel must screen project candidates along with primary responsibilities. Internal technology transfer organizations have the knowledge and leverage to facilitate the best transfer partnerships.

8B: Level of decision making control in the technology transfer organization. In concert with attributes 7A and 8A, technology transfer organizations contained within developing organizations often have authority to make most decisions. Decision authority within the technology transfer organization avoids potential bureaucratic hurdles in the transfer process.

10A: Marketing and advertising of technologies targeted to relevant industries. Federal laboratory standard practice is to advertise technologies in the same publications regardless of the technology. Successful transfer organizations target marketing efforts at more relevant industries. 4 of 5 failures relied upon the standard practice or neglected

advertising altogether. Inadequate advertising reduces opportunity for locating highly capable acquirers.

11C: Scientists and engineers (potential developers) are encouraged to develop commercializable technologies. Part of an active, positive transfer culture is an environment of innovation. Successful developing organizations encourage personnel to develop new technologies. New technologies benefit developing organizations' primary customers and potential transfer recipients by exposing new opportunities.

Acquirer Findings

Table 4-7 summarizes primary findings related to the acquiring organization.

Table 4-7. Summary Acquirer Findings

Sub-Attribute	*Attribute Description*
3A	Organization structure facilitates informal technology transfer processes
6B	How technology transfer projects are funded
9C	Business plan exists for receiving technologies
14B	The technology matches the technological capabilities of one of its operating units and one of its principal markets

3A: Organization structure facilitates informal technology transfer processes. A positive transfer culture will encourage informal transfer processes. Failure transfer action organizations did not hinder unconventional transfer methods. But successes are proactive and "empowered" personnel to exploit technologies. Stronger management conviction to instilled a positive transfer culture increases the opportunity for success.

6B: How technology transfer projects are funded. In contrast to developer funding, acquirer funding is a significant indicator of success. The data indicates that strong acquirer funding is prevalent in success transfers. While the majority of definite success transfer projects utilized dedicated project funding, no failures had such a luxury. Failures either had no formal funding, relied upon organizational accounts, or obtained funds from pools of technology transfer money.

9C: Business plan exists for receiving technologies. All three analysis methods presented in this chapter expose a business plan as one of the most significant activities successful acquiring organizations perform. A fully developed business plan is a step-by-step manuscript outlining efforts from development to sales forecasts. Business plan development forces implementors to face tough issues at the initial stages of the transfer project. The effort may lead to proactive measures to address weaknesses prior to large resource commitments.

14B: The technology matches the technological capabilities of one of its operating units and one of its principal markets. The strategic fit between acquirer capabilities and technology characteristics is a critical success attribute. Although strategic fit does not guarantee success, transfers where the technology matches acquirer technical capabilities and strategic objectives, have better opportunity for successful outcome. One individual representing a technology transfer failure confided that although it was not recognized at conception, company personnel were ill-prepared to work with advanced technologies.

Findings Applicable To Developers and Acquirers

Table 4-8 summarizes findings characteristic of both developers and acquirers.

Table 4-8. Summary Findings For Both Developer and Acquirer

Sub-Attribute	*Attribute Description*
4A	Both parties are in similar industries
4B	Both parties have similar personnel composition
5A	Developer and acquirer are located near one another ***(not necessary)***
15A	Interface is maintained between organizations
15C	Organizations share personnel during the transfer and development process

4A: Both parties are in similar industries. A similar technology application or focus between transfer partners assists cooperative efforts. All definite "success" partners perfectly matched in regard to technology application. Half of the failures had disconnects due to mismatched technology applications.

4B: Both parties have similar personnel composition. Strategic fit between developer and acquirer organizations is dependent upon similar technology application or focus, and similar personnel. Particularly, acquirer capability to work alongside developing organization scientists is critical. Two failures did not have adequate technical capability and were unable to successfully execute the transfer project.

5A: Developer and acquirer are located near one another. The location of transfer partners does *not* affect success or failures. Half of the definite successes are long distance partners, while all of the failures reside within 100 miles of one another. Personal communication and conventional mail are no longer necessities of modern business

operations. Electronic mail, facsimile, and video conferencing allow distant partners to quickly exchange information with ease and reliability.

15A: Interface is maintained between organizations. Transfer partners that communicate regularly throughout the project's life cycle maintain higher awareness, work together better, and succeed more often. Definite successes exhibited these characteristics, while some failures did not regularly meet with their transfer partners to discuss progress or other aspects.

15E: Organizations share personnel during the transfer and development process. The data is convincing. All transfer actions categorized as definite successes share personnel during the technology transfer project. This is a level of involvement beyond meetings. In most cases, acquiring and developing personnel worked together on development efforts and in research laboratories. Failures exclusively did not share personnel. This explains difficulties and cancellations caused by poor communication and technical understanding

Conclusion

The summary results provide basis for recommendations for improving DOD technology transfer strategies. First, some key findings exhibit qualities of necessary conditions. That is, the presence (absence) of certain characteristics ensure (prevent) successful completion of technology transfer projects. These attributes are categorized in the next chapter as either:

a) Necessary conditions for successful technology transfer; also known as

b) "Show-stoppers" which when absent lead to unsuccessful transfers

Second, key developer organization findings will facilitate formulation of recommendations for implementation at Department of Defense laboratories. Third, key acquirer organization findings will identify how federal laboratories should select potential

technology transfer partners. Finally, issues related to the strategic fit of the developing and acquiring organizations with the technology will be highlighted.

V. Conclusions and Recommendations

Chapter Overview

This chapter structures the results of the research effort in a manner that addresses the objectives of this study. Namely, strategic recommendations for federal laboratories are provided. Recommendations will address strategies that effect all three principle parties. The first section identifies conditions that the data indicate are necessary for successful technology transfer. These characteristics are "show-stoppers" and their absence lead to unsuccessful transfer actions. The second section addresses recommendations to be implemented internally by developing organizations (federal laboratories). The third section will propose recommendations to improve procedures for selecting optimum acquirer partners (private industry). The fourth section will recommend methods for evaluating the strategic fit of the technology in relation to developer and acquirer characteristics and capabilities. Finally, a number of potential extensions to this research are provided. As a prelude to the recommendation section, this chapter will revisit the fundamental motivation and key issues surrounding federal to commercial technology transfer.

Review

The literature review exposed technology transfer as a 2 to 3 decade-old political issue. It was not until the 1980s that technology transfer became a political and socio-economic force. The disrupted balance of international trade and loss of technical superiority in key industries heightened national awareness of technology transfer. As awareness and education concerning technology transfer increased, realization of the potential benefits became evident. Several entities benefit from technology transfer.

Laboratories benefit from increased exposure generated by successful or "glamorous" technologies. Also, technology transfer projects provide superb training for laboratory personnel. Transfer projects enable scientists to expand beyond the scope of typical laboratory research efforts. Additionally, license and cooperative agreements provide revenue generating capability for laboratory developing organizations and inventors.

The Federal Government benefits through the efficient use of research and development funding. In addition to supporting primary defense and other federal agency requirements, technology transfer enables private industry to benefit from federal research and development funds. Even the most exotic federal research efforts often have commercial applicability.

Arguably, the most obvious benefactor is private industry. US industry research and development expenditures, as a percentage of revenue, lag behind other economic powers. Technology transfer can be an inexpensive, low risk addition to corporate research. Federal laboratories can provide corporations assistance at multiple stages in the research and development process. Laboratories can be the source of new concepts and innovations, or laboratories can assist in the maturation of internally developed corporate innovations. Laboratory assistance may decrease the time it requires to develop technologies for market entry. Short development lead times maintain product superiority and technical advantage, entities which separate industry leaders from followers. In addition, laboratories are an inexpensive alternative source for consultation. Interaction between laboratory and private industry personnel may create opportunities and learning experiences previously unavailable. The opportunity for reduced costs and improved technology capability is promising if rates of successful technology transfer can be improved. Successful transfers support the national industrial base and international competitiveness. During an era of scarce resources and increased consumer demand for

high technology, federal to commercial technology transfer is an opportunity Federal Government, laboratories, and private industry can not afford to ignore.

Recommendations

Based upon the analysis and results presented in Chapter Four, this section will provide recommendations which seek to improve the rate of successful technology transfer. Recommendations are segregated into four sections. The first section highlights conditions necessary for successful technology transfer. The absence of necessary conditions are "show-stoppers" and lead to project failure. The second section encompasses recommendations for changes within Federal Laboratories. The third section addresses acquirers, and the qualities characteristic of successful acquirers. This area pinpoints laboratory strategies to identify the best acquirer for each technology transfer action. The final section addresses technologies and how they should fit with developers and acquirer characteristic.

Necessary Conditions and "Show-stoppers". Data indicate that certain conditions must be present for transfer projects to succeed. Identification of necessary conditions for successful technology transfer can contribute to meaningful technology transfer policy formulation. "Show-stoppers" are the absence of necessary conditions that lead to failure. DOD technology transfer policy must ensure laboratories are empowered with awareness of vital attributes of technology transfer. Table 5-1 summarizes technology transfer necessary conditions.

Table 5-1. Necessary Conditions

1. Developer organizations require upper management that tracks and supports current technology transfer projects, actively seeks new transfer opportunities, and provides an environment or culture which promotes technology transfer (centralized support/control).
2. Key developer personnel (inventors/"champions") involved in the transfer project from initiation to closure. Developer involvement in identifying potential markets and potential acquirers essential to successful transfer.
a. When external transfer organizations initiate transfers, the developing organization must examine acquirers for capability and fit.
3. Developer and acquirer transfer teams share personnel through the project life-cycle.
4. Acquirer organizations must have the capability and resources to understand and develop the technology.
5. Acquiring organizations need a business plan for commercializing fruits of technology transfer projects.
6. Acquirer organizations must conduct market research to identify alternative technology applications, markets, and potential customers.

Chapter Two reveals several previous studies that identify findings similar to the necessary conditions described above. For instance, Dr. Robert Carr identifies "management encouragement and support" as an essential ingredient to successful technology transfer (6:25). Derived from this study's findings, necessary condition 1 similarly describes a positive transfer management culture as conducive to successful technology transfer. Additionally, Sauder, Nasher, and Padmanabhan conclude that technology "champion" involvement is a technology transfer best practice (18:10). Necessary condition 2, stresses life cycle involvement of the "champion" as a prerequisite for successful technology transfer.

Recommendations for DOD Transfer Strategies. This section proposes recommendations for Government laboratory strategies that improve opportunity for successful technology transfer. Several findings overlap with necessary conditions previously discussed. Table 5-2 identifies strategies for improving defense technology transfer.

Table 5-2. Recommendations for DOD Transfer Strategies

1. Ensure top management maintains high awareness and tracks technology transfer progress (centralized control/support).
2. Technology transfer funding and dedicated staffing is insignificant compared to the effects of the individual developer. Ensure this key individual is an integral component of the technology transfer process (decentralized execution).
3. Empower transfer organizations with autonomy to facilitate transfer actions with minimal bureaucratic controls (decentralized execution).
4. Ensure developer organizations have technically proficient transfer agent or organization located within the developing organization.
5. Developer organizations must market and advertise candidate transfer technologies to relevant industries.
6. Developers need to maintain regular interface meetings with the acquiring organization.
7. Developer and acquirer transfer teams share personnel throughout the project life-cycle.

The literature is consistent with this study's recommendations for DOD transfer strategies. Souder, Nasher, and Padmanabhan's study identify "open interactions" and "joint transfer teams" among developer and acquirer personnel as a technology transfer best practice (18:10). This study concludes that regular interface meetings (necessary condition 6) and sharing personnel (necessary condition 7) essential to successful

transfers. In Chapter Two, Gibson and Niwa's Communication Based Model illustrates the joint effort between developer and acquirer teams (11:179).

Acquirer Selection Strategies. Federal laboratories have the opportunity to select acquirers most capable of successfully completing transfer projects. Presently, laboratory standard practice does not include evaluation of acquirer capabilities. Table 5-3 highlights key strategies for selecting acquirers most likely to successfully commercialize laboratory technologies.

Table 5-3. Acquirer Selection Strategies

1. Ensure acquirer has capability to fund project through completion and/or product commercialization.
2. Ensure acquirer management supports informal technology transfer processes.
3. Require acquirer to develop a business plan for commercializing the technology.
4. Ensure acquirer has technical capability and resources to understand and develop the technology.
5. Ensure strategic fit between developing and acquiring organizations. a. First, acquirers' principle industry should relate to the technology and the focus of the laboratory unit. b. Second, personnel compositions among developers and acquirers should be similar in regard to education and capabilities.
6. Require acquirer to attend scheduled interface meetings.
7. Seek acquirers willing to share personnel throughout the project life-cycle.
8. It is not necessary to seek acquirers located near the laboratory.

Wood and EerNisse emphasize the necessity for acquiring organizations to have the internal capability to develop the technology into a commercial product (20:25). In concert with Wood and EerNisse, selection strategy 4 recommends selecting acquirers

with technical capabilities and resources sufficient to develop the technology. Additionally, acquirers must have sufficient funding to complete transfer projects. Wood and EerNisse emphasize acquirer capital sufficient to sustain product development and sales (20:28).

Strategies Affecting Technologies. The final link to an all-encompassing strategy regarding federal technology transfer is analysis of technology characteristics in relation to developer and acquirer capabilities. Table 5-4 summarizes technology characteristics.

Table 5-4. Strategies Affecting Technologies

1. Acquiring organization's primary industry should match the developing organization's technology application.
2. Acquirer personnel should have the expertise necessary to understand and further develop the technology.

Strategic fit between developer, acquirer, and technology is a critical element. In order to benefit from interaction with developer teams, acquirer application of the technology should be related to the developer's technology focus. Diverging technology applications, diffuse the benefit resulting from interaction and shared effort.

Areas For Further Research

The exploratory nature and breadth of coverage of this effort opens several possibilities for further research. Ideas for further research are described below.

Research Proposal 1: Methods for marketing technologies to industry. Federal laboratories need to advance their marketing and advertising techniques. Some

laboratories have adopted progressive methods that attract highly capable acquirers. This study will identify potential marketing methods for laboratory implementation.

Research Proposal 2: A case study on improved acquirer selection methods. Data indicate that highly capable acquirers are more likely to produce favorable transfer outcomes. Evaluation of acquirer capabilities prior to selection will result in selection of an acquirer most capable of succeeding with a given transfer project.

Research Proposal 3: Analysis of external transfer organizations and their effect upon Federal to commercial technology transfer outcomes. Data indicate that transfers facilitated by external transfer organizations are less likely to succeed. Further analysis is required to support this research and provide recommendations to augment externally facilitated transfer to ensure improved success rates.

Research Proposal 4: Analysis technology transfer support organizations. Technology transfer support organizations may be able to provide timely assistance. Research indicates that developing organizations need support in patent related issues, market research, and overcoming bureaucratic hurdles. Support organizations may be able to increase awards and incentives to technology developers. This research can address how such organizations assist technology transfer efforts or cause unnecessary bureaucratic hurdles.

Research Proposal 5: Analysis of leading commercial and university technology transfer opportunities. Numerous private corporations and universities have been identified by literature as leaders in successful technology transfer. Further study of

literature and companies and universities may provide insight into measures for federal implementation.

Research Proposal 6: Ideas for increasing royalty income. As federal laboratories increase the number and quality of transfer projects, expectations for royalty income will increase. The research goal is to determine measures laboratories take to increase royalty potential.

Research Proposal 7: Creation of a transfer evaluation system. A transfer evaluation system examines critical components of potential transfer projects and evaluates the opportunity they present. A system can predict success, evaluate components such as acquirer organizations or technology capabilities.

Summary

The objective of this thesis was to recommend strategies for improving federal to commercial technology transfer, in particular, technology transfers emanating from Air Force laboratories. The goal was to identify successful attributes and compare the attributes to actual technology transfer projects.

Previous literature identified a waterfront of successful transfer attributes and models. This study began with a thorough baseline of successful attributes. Conclusions have narrowed the scope to a manageable list of strategies for Air Force consideration. Of utmost importance are necessary conditions; the absence of necessary conditions predict transfer project failure. Agencies seeking improvements in the number of successful technology transfer projects may consider these strategies directed at federal laboratories, acquirer selection, and technologies.

Appendix A. Technology Transfer Legislation

Table 1
Summary of Technology Transfer Legislation, Executive Orders, and Air Force Directives

Year	Public Law (P.L.)	Name	Major Elements (Purpose)
1966	P.L. 89-554	Freedom of Information Act (FOIA)	• Provided a vehicle to inform the public about Federal Government activities • Provided the right to request agency records and have them made available promptly
1980	P.L. 96-480	Stevenson-Wydler Technology Innovation Act	• Established technology transfer as a mission of the Federal Government • Established ORTAs
1980	P.L. 96-517	Bayh-Dole Act	• Superseded all previous laws that give small businesses and nonprofit organizations (including universities) certain rights related to inventions they developed under funding agreements with the Government (Did not give maintenance and operation (M&O) contractors right to elect title to its inventions.) • Protected descriptions of inventions from public dissemination and FOIA for reasonable period of time to file patent applications
1984	P.L. 98-620	Trademark Clarification Act	• Amended Bayh-Dole to permit M&O contractors to elect title to inventions in exceptional circumstances and national security funded technologies
1986	P.L. 99-502	Federal Technology Transfer Act (FTTA)	• Authorized CRDAs for Government-owned Government-operated (GOGOs) organizations • Established FLC • Provided a preference to U.S.-based business • Established technology transfer as a laboratory mission
1987	N/A	Executive Order 12591, Facilitating Access to Science and Technology	• Emphasized U.S. commitment to technology transfer • Required Government agencies to delegate authority to Government-operated laboratories to enter into cooperative agreements to the extent they are legally capable and provided authority to improve the global trade position of the United States

Table 1
Summary of Technology Transfer Legislation, Executive Orders, and Air Force Directives

Year	Public Law (P.L.)	Name	Major Elements (Purpose)
1988	P.L. 100-418	Omnibus Trade and Competitiveness Act	• Mandated the establishment of regional university-based Manufacturing Technology Centers for transferring advanced manufacturing techniques to small- and medium-sized firms
1988	DoD 3200.12-R-4	Domestic Technology Transfer Program Regulation	• DoD Response to P.L. 99-502 • Stipulates responsibilities for heads of DoD Components • Authorizes use of CRDAs • Stipulates use of awards and royalties
1989	P.L. 101-189	National Competitiveness Technology Transfer Act (NCTTA)	• Authorized CRDAs for Government-owned Contractor-operated (GOCOs) organizations • Protects trade secret information brought into or developed under a CRDA from disclosure under FOIA
1990	Air Force Policy Directive (AFPD) 61-3	Air Force Domestic Technology Transfer Policy Directive	• Established Air Force policy for technology transfer • Provides procedures for CRDAs • Defines responsibilities of ORTAs
1991	P.L. 101-510	Defense Authorization Act	• Authorized federal laboratories and Federally Funded Research and Development Centers (FFRDCs) to award contracts to a partnership intermediary for services that increase the likelihood of laboratory success in joint activities with small business firms.
1991	P.L. 102-245	American Technology Preeminence Act	• Extended FLC mandate through 1996 • Allowed exchange of intellectual property between participants in a CRDA • Required a report on the advisability of CRDAs that would permit federal contribution of funds, • Allowed laboratory directors to give excess equipment to educational institutions or nonprofit organizations as a gift
1992	P.L. 102-564	Small Business Technology Transfer (STTR) Act	• Established the STTR program

Appendix B. Attributes of Successful Technology Transfer

ATTRIBUTES OF SUCCESSFUL TECHNOLOGY TRANSFER

1) **High Level Commitment (to overall T.T. policy)**

   a. Top management abreast of T.T. projects and involved in tracking them. (D,A)

   b. Resources are made available to actively seek T.T. opportunities (D,A)

   c. Management has a written, formal plan for promoting T.T. (D)

2) **High Level Commitment (to specific transfer)**

   a. Organization has a formal commitment to the specific T.T. (D,A)

   b. T.T. project granted adequate financial and personnel resources. (D,A)

3) **Informal Processes**

   a. Organization structure facilitates informal T.T. processes. (D,A)

   b. Procedures are in place for requesting funds for T.T. projects. (D,A)

   c. Technology "champion" is present. (D)

   d. Product "champion" is present. (A)

4) **Strategic Fit (developer - acquirer)**

   a. Both parties are in similar industries. (D,A)

   b. Both parties have similar personnel composition. (D,A)

5) **Location**

   a. Developer and acquirer are located near one another. (D,A)

6) **Funding, staffing, and facilities**

a. How T.T. projects are staffed. (D,A)

b. How T.T. projects are funded (D,A)

c. Facilities are in place for developmental research and production. (A)

d. Organization has, on staff, personnel experienced in the subject technology. (A)

e. Organization has personnel experienced in development and production. (A)

f. Technology developing organization is large enough to handle all functions of research and project control including marketing products and technology. (D)

g. Acquiring organization is large enough to handle all functions of product development, project control, manufacturing, and marketing. (A)

7) **Experienced technology transfer organization and strategy (developer).**

a. Closeness of the transfer agent to the developing organization. (D)

b. Organization has a formal, writen process for T.T. (D)

c. T.T. strategy involves the inventor in the T.T. process (D)

d. Inventor allowed to dedicate "corporate" time to the transfer project. (D)

e. Organization has completed T.Ts'. (D)

8) **Autonomy**

a. Organization has a T.T. organization (D,A)

b. Level of decision making control in the T.T. organization. (D,A)

9) Product Development and Commercialization Experience (Acquirer)

a. Organization has completed T.Ts. (A)

b. Formal process plan exists for receiving technologies. (A)

c. Business plan exists for commercializing technology. (A)

d. Where does organization develop products.

10) Entrepreneurial

a. Marketing and advertising of technologies targeted to relevant industries. (D)

b. Technology maturation supported by internal units or by contracting out. (D,A)

c. Cooperative agreements and incentive arrangements encouraged to facilitate T.T. (D)

11) Science and technology staffs.

a. Developers (scientists/technologists) participate in the technology transfer process. (D)

b. Developers have incentives to see technology commercialized:

c. Scientist and engineers (potential developers) are encouraged to develop commercializable technologies. (D)

d. Active involvement in professional community. (D,A)

e. The laboratory has a formal recognition process for developers and key individuals. (D)

12) Technology evaluation and patenting.

a. Organization has incentives for identification of intellectual property. (D)
b. Organization has a dedicated support staff for the patenting process. (D)

c. Outside experts allowed access in order to identify technologies attractive to industry. (D)

d. Market research is done in-house, or by contract, on potential technology applications. (D,A)

e. Inventors requested to identify potential markets and interested firms. (D)

13) Qualities of commercial adaptability (technology).

a. Tangible value--new technology, when compared side-by-side with status quo provides noticeable improvement. (T)

b. Divisibility--technology can be brought to the market in smaller, less dramatic, less risky forms. (T)

c. Diverse market applications. (T)

d. Exclusive property rights (patents) obtained or obtainable.

e. Ability to improve proprietary coverage is possible. (T)

14) Strategic fit (technology - acquirer).

a. The technology is presented at a time when the organization can commit resources. (A)

b. The technology matches the technological capabilities of one of its operating units and one of its operating markets. (T,A)

c. Personnel have capability to understand, maintain, and further develop technology on its own. (A)

15) Life-cycle interaction

a. Product champions maintain interface between organizations. (D,A)

b. Incentives provided to the developing organization personnel are structured to encourage cooperation after initial commercial development and throughout the product life-cycle. (D,A)

c. Acquirer sought input from developer during cost and schedule estimate formulation. (D,A,)

d. Both parties perceive organizational benefit from commercial product development. (D,A)

e. Organizations share personnel during the transfer and development process. (D,A)

Appendix C. Survey For Developing Organizations

Survey

ATTRIBUTES OF TECHNOLOGY TRANSFER
(Originating Organization)

Administrative

1. Name: _____

2. Position: _____

3. Business Address: _____
   _____
   _____
   _____

4. Phone Number: _____

General

1. What is the most appropriate, most predominant name for the subject technology?

2. What technological discipline is it from?

3. Briefly describe the technology.

4. What is your role in technology transfer and/or technology development (inventor, technical point of contact, spokesperson, manager)?

5. How would you define technology transfer?

6. Does this case fit your description of technology transfer?

a. Yes
b. No
Explain:_____

7. How would you define success in technology transfer?

8. In your opinion, rate the success of the technology transfer.

1 2 3 4 5 6 7 8 9 10

9. What level of maturity is the technology at the time of the transfer (ie basic)?

10. Has the maturity of the technology evolved since the beginning of the transfer?

11. If a commercial product is a goal of this technology transfer, has a product been developed?

Yes No

12. If you answered no, when do you estimated completion of a developed commercial product

13. How would you describe the technology transfer process?

14. In your best judgment, when did the technology transfer process begin; end; is it still in progress?

15. Can you cite any examples of actions that may have improved the level of success of the transfer?

1A1. Does your management team have a system for tracking technology transfer program progress? (D,A)

a. Yes, progress tracking is a highly visible, integral part of the technology transfer process.
b. Yes, I am aware of a system
c. Yes, but it is not regularly used
d. No

1A2. Does your management team keep abreast of technology transfer progress? (D,A)

a. Yes, frequent, planned meetings and/or reports are submitted to management
b. Yes, periodic, planned meeting and/or reports are submitted to management
c. Yes, infrequent, unplanned meetings and reports are requested from management
d. No

1B1. Are personnel located in your organization involved in seeking technology transfer opportunities? (D,A)

a. Yes, fully dedicated team
b. Yes, fully dedicated individual
c. Yes, included in the duties of personnel with other primary responsibilities
d. No

1B2. Are funds allocated for seeking technology transfer opportunities? (D,A)

a. Yes, separately funded portion of the corporate/organizational budget
b. Yes, part of some organizations' budgets but not separately funded
c. No funds allocated

1B3. Are facilities available to house technology transfer seeking activities? (D,A)

a. Yes, separate offices are provided for technology transfer personnel
b. Yes, space is provided for technology transfer personnel
c. Yes, but personnel remain in their functional office space
d. No

1C1. Does management have a written/formal plan for promoting technology transfer? (D)

a. Yes, plan is heavily promoted internally and outside the organization
b. Yes, plan is heavily promoted internally
c. Yes, plan is heavily promoted outside the organization
d. Yes, I have seen the plan
e. Yes, but I have not seen it
f. No

2A1. Do you feel that technology transfer is an important part of your job responsibility? (D,A)

a. Yes, highly important
b. Yes, moderately important
c. Somewhat important
d. No
e. No, specifically directed not to engage in technology transfer activities

2A2. Do you feel your organization is committed to technology transfer? (D,A)

a. Yes, highly committed
b. Yes, moderately committed
c. Somewhat
d. No

2B1. Are technology transfer projects allocated corporate financial resources? (D,A)

a. Yes, enough to do the job well
b. Yes, but limited funding reduces potential
c. Yes, but other funds necessary
d. No, must fund from organizational budgets
e. No

3A1. Does your organization facilitate informal ways to exploit potential transfers? (D,A)

a. Yes, policy empowers employees to exploit technologies
b. Yes, organization structure does not inhibit unconventional methods
c. Yes, but guidelines exist for proper procedures
d. No, bureaucratic structure inhibits informal transfer processes

3B1. How do individuals or organizations request funds for technology transfer projects? (D,A)

a. Streamlined procedures exist for funds requests
b. Written formal procedures similar to procedures for other corporate projects
c. Guidelines exist for methods to seek access to funds
d. Informal, political process is status quo
e. Unsure
f. Other: _____

3C1. Did this transfer action have a "technology champion" to promote and shepherd the technology through bureaucratic obstacles? (D)

a. Yes, the individual was the inventor
b. Yes, the individual was the inventor's superior
c. Yes the individual was a high level manager
d. Yes, a transfer support organization assisted
e. Yes, other:_____
f. No

4A2. What military purpose was the technology designed for? (D) _____
_____

4B2. What description best fits your organization's personnel composition? (D,A)

a. Scientific -- mostly Ph.D.s
b. Science/Highly technical -- Many Ph.D.s and engineers
c. Highly technical -- Mostly engineers
d. Low technical -- Mostly engineers
e. Bureaucratic/Administrative
f. Other:_____

5A1. What is the distance between your organization and your transfer partner? (D,A)

a. Within 50 miles
b. Within 100 miles
c. Greater than 100 miles

6A1. How are technology transfer projects staffed? (D,A)

a. Fully dedicated teams
b. Teams are formed and time is made available, but project is an additional responsibility
c. Teams are formed but time is not set aside and project is an additional responsibility
d. No teams or dedicated time
e. Other:_____

6B1. How are technology transfer projects funded? (D,A)

a. Dedicated project funding
b. Technology transfer pools of money and projects compete for funds
c. Funds included in organizational accounts
d. No formal funding
e. Unsure
f. Other:_____

6B2. Do technology transfer projects compete against one another for funding? (D,A)

a. Yes, always
b. Yes, with exceptions
c. No

6F1. What best describes the support capabilities (patent assistance, marketing, administration) of the technology developing organization? (D)

a. Organization has a well staffed transfer support function to include patent assistance, project control, marketing, and administration
b. Organization has a support staff that provides assistance
c. Organization has support which seems to hinder progress
d. No support function

6G1. What best describes the capabilities of the acquiring organization in respect to development and project control? (D)

a. Organization has ample resources to support development, project control, manufacturing, and marketing
b. Organization has resources in most areas but may lack in some
c. Less than adequate capabilities

7A1. What is the closeness of the transfer agent to the developing organization? (D)

a. Same person
b. Close associate with similar technical expertise
c. Located in the same organization
d. From a separate transfer organization
e. Outside party

7-8A2. How close is the T.T. organization to the technology development organization? (D)

a. T.T. organization is part of technology development lab
b. T.T. organization is part of lab headquarters
c. T.T. organization is external to the lab
d. T.T. organization is an outside party (contracted)
e. Other: _____

7B1. Does the developing organization have a written process plan for T.T.? (D)

a. Yes, formal process plan actively utilized and strictly adhered
b. Yes, process plan serves as a blueprint for T.T.
c. Yes, plan exists but it is rarely referenced or used
d. No written process plan

7B2. At what level was the plan established? (D)

a. high level management level
b. middle management level
c. immediate organization
d. other: _____

7C1. What best describes developer involvement in the T.T. process? (D)

a. Mostly technical and administrative duties
b. Mainly technical responsibilities
c. Level of involvement varies from project to project

7D1. Is developer allowed to dedicate "company" time to transfer projects? (D)

a. Yes, involvement is part of the job responsibility and it is highly encouraged
b. Yes, involvement on "official" projects encouraged
c. Yes, but other job responsibilities maintain priority
d. No

7E1. What is the T.T. experience level of your organization? (D)

a. History of numerous, highly complex T.T.s
b. Only recent involvement (less than 2 years) but some complex actions
c. Only recent involvement in less complex T.T.s
d. This was/is one of our first experiences

7E2. What is the complexity of this transfer relative to other transfers you are aware of? (D)

a. This transfer is more complex
b. This transfer similar in complexity to past actions
c. This transfer is less complex

8B1. What is the level of decision making authority in the T.T. organization? (D,A)

a. Complete decision making authority
b. Authority to make most decisions
c. Limited authority: projects are identified and tasked by higher authority
d. No authority

10A1. How does your organization market technologies? (D)

a. Effort directed only at relevant, targeted industries
b. Use same publications and methods regardless of the technology
c. Combination of (a) and (b)
d. No formal marketing

10B1. Do you further develop technologies, beyond internal requirement, solely for T.T. potential? (D)

a. Yes, we internally support technology maturation for T.T. purposes
b. Yes, we contract for technology maturation for promising technologies
c. No, we do not further develop technologies beyond internal requirements

10C1. What T.T. vehicles are used? (D)

a. CRDAs
b. Licensing
c. SBIRs
d. No vehicles used - informal process
e. Combination: _____

10C2. Any incentive arrangements granted to acquirers to encourage T.T.? (D)

a. Exclusive rights
b. Patents
c. Funds
d. Personnel
e. All of the above
f. Combination: _____
g. None

11A1. What is the level of participation of developers in the T.T. process? (D)

a. Formal responsibilities delineated in T.T. plans and strategy documents
b. Participation part of job responsibilities and it is highly encouraged
c. Participate if time allows
d. Hand off knowledge and technology and return to normal duties

11-15B1. Are developers incentivized to see technologies commercialized? (D)

a. Inventors receive royalties based upon commercial success
b. Royalties returned directly to benefit developing unit
c. Developers allowed life-cycle involvement in projects
d. All of the above
e. Combination: _____

11C1. How are potential developers (inventors) encouraged to develop technologies? (D)

a. Citations and rewards sponsored by management
b. Achievers submitted for monetary rewards
c. Achievers are submitted for national rewards
d. Projects granted "extra" funding
e. All of the above

11D1. Are developers actively involved in their professional community? (D)

a. Expected to participate in conferences, publish, and interact with colleagues (funds are easily granted)
b. Encouraged to participate in conferences, publish, and interact with colleagues (funds are easily granted)
c. Involvement accepted but funds are not easily obtained
d. No funds allocated

11D2. Are you aware of any T.T. opportunities arising from professional community involvement? (D)

a. Yes, several
b. Yes
c. No

11E1. Does lab have a recognition process for developers and key participants? (D)

a. For those instrumental in technological breakthroughs
b. For those instrumental in incremental technology, product, or process improvements
c. For those who facilitate T.T.
d. For those instrumental in affecting commercial success of technology
e. All of the above
f. Other: _____

12A1. Does organization have incentives for identifying intellectual property? (D)

a. Awards and money available for those who identify intellectual property
b. Personnel trained and encouraged to identify intellectual property
c. No

12B1. Does organization have a trained support staff for the patent process? (D)

a. Yes, an office has sole responsibility for administering patenting process
b. Yes, a specific individual(s) in the legal office handles this function
c. Yes, an office supports but it is a shared effort
d. Yes, a legal office supports but developing unit does the work
e. No

12C1. Does industry have the opportunity to identify fruitful technologies from your laboratory? (D)

a. Yes, all research projects are abstracted and made available to industry
Where: _____
b. Yes, industry allowed access to lab facilities to see opportunities first hand
c. Yes, T.T. specialists review lab technologies
d. No

12D2. How is market research conducted on technologies (D)

a. A formal, intensive in-house market research
b. An informal in-house analysis
c. Most often, market analysis is contracted out
d. Most often this task is left for the acquirer

12E1. Are inventors requested to identify potential markets or interested firms? (D)

a. Inventors often tasked to identify potential contacts
b. Inventor input is sometimes requested
c. Rarely is the inventor involved

13A1. How does the technology affect existing product markets? (D,A)

a. It creates a new market
b. It replaces existing products
c. It modifies or improves an existing product technology
d. It provides an equal, alternative approach to the status quo
e. It is a less sophisticated, low cost alternative

13B1. In regard to the technology, how can it be brought to the market? (D,A)

a. It is divisible -- it can be developed and included in products in small, less dramatic increments
b. Technology must be included as a complete package
c. Other:_____

13C1. How does the technology fit into the market(s)? (D,A)

a. Technology has multiple applications in several diverse markets
b. Technology has multiple applications in one market
c. Technology fits into one market
d. Market has not been identified

13DE1. How does the industry, the transfer, and other factors affect property rights? (D,A)

a. We own the property rights and any improvements to the technology (patent)
b. We own the property rights but the other party can patent improvements
c. Other party owns property rights, but we can patent improvements
d. We share patent rights with the other party
e. We have no ability to gain patent rights

15A1. Are interactions between the transfer partners maintained throughout a technology's and subsequently a product's lifecycle? (D,A)

a. Yes, scheduled, periodic meetings are held
b. Yes, interface is initiated on an "as needed" basis
c. No planned interface after initial transfer

15A2. Who typically interfaces with the transfer partner? (D)

a. Inventor
b. Someone close to the technology
c. Organization spokesperson
d. T.T. organization
e. Other: _____

15C1. Did acquiring team seek input from the developer during cost and schedule estimate formulation? (D,A)

a. Yes, a member of the developing unit was an integral part of the cost and schedule estimation
b. Yes, input was requested from a member of the developing organization
c. Developing organization was not involved

15D1. At what point does a transfer benefit your organization? (D)

a. At point of technology transfer
b. At point of product/process development
c. At point product/process becomes financial success
d. It doesn't

15E1. Did your T.T. partners share personnel during the transfer and development? (D,A)

a. Yes
b. No

15F1. When did the developer and acquirer communicate technical aspects of the transfer? (D,A)

a. Long before the transfer was initiated
b. Close to the point of transfer
c. After the transfer agreement was initiated

Appendix D. Survey For Acquiring Organizations

Survey

ATTRIBUTES OF TECHNOLOGY TRANSFER
(Acquiring Organization)

Administrative

1. Name: _____

2. Position: _____

3. Business Address: _____
   _____
   _____
   _____

4. Phone Number: _____

General

1. What is the most appropriate, most predominant name for the subject technology?

2. What technological discipline is it from?

3. Briefly describe the technology.

4. What is your role in technology transfer and/or technology development (inventor, technical point of contact, spokesperson, manager)?

5. How would you define technology transfer?

6. Does this case fit your description of technology transfer?

a. Yes
b. No
Explain:_____

7. How would you define success in technology transfer?

8. In your opinion, rate the success of the technology transfer.

1 2 3 4 5 6 7 8 9 10

9. What level of maturity is the technology at the time of the transfer (ie basic)?

10. Has the maturity of the technology evolved since the beginning of the transfer?

11. If a commercial product is a goal of this technology transfer, has a product been developed?

Yes No

12. If you answered no, when do you estimated completion of a developed commercial product

13. How would you describe the technology transfer process?

14. In your best judgment, when did the technology transfer process begin; end; is it still in progress?

15. Can you cite any examples of actions that may have improved the level of success of the transfer?

1A1. Does your management team have a system for tracking technology transfer program progress? (D,A)

a. Yes, progress tracking is a highly visible, integral part of the technology transfer process.
b. Yes, I am aware of a system
c. Yes, but it is not regularly used
d. No

1A2. Does your management team keep abreast of technology transfer progress? (D,A)

a. Yes, frequent, planned meetings and/or reports are submitted to management
b. Yes, periodic, planned meeting and/or reports are submitted to management
c. Yes, infrequent, unplanned meetings and reports are requested from management
d. No

1B1. Are personnel located in your organization involved in seeking technology transfer opportunities? (D,A)

a. Yes, fully dedicated team
b. Yes, fully dedicated individual
c. Yes, included in the duties of personnel with other primary responsibilities
d. No

1B2. Are funds allocated for seeking technology transfer opportunities? (D,A)

a. Yes, separately funded portion of the corporate/organizational budget
b. Yes, part of some organizations' budgets but not separately funded
c. No funds allocated

1B3. Are facilities available to house technology transfer seeking activities? (D,A)

a. Yes, separate offices are provided for technology transfer personnel
b. Yes, space is provided for technology transfer personnel
c. Yes, but personnel remain in their functional office space
d. No

2A1. Do you feel that technology transfer is an important part of your job responsibility? (D,A)

a. Yes, highly important
b. Yes, moderately important
c. Somewhat important
d. No
e. No, specifically directed not to engage in technology transfer activities

2A2. Do you feel your organization is committed to technology transfer? (D,A)

a. Yes, highly committed
b. Yes, moderately committed
c. Somewhat
d. No

2B1. Are technology transfer projects allocated corporate financial resources? (D,A)

a. Yes, enough to do the job well
b. Yes, but limited funding reduces potential
c. Yes, but other funds necessary
d. No, must fund from organizational budgets
e. No

3A1. Does your organization facilitate informal ways to exploit potential transfers? (D,A)

a. Yes, policy empowers employees to exploit technologies
b. Yes, organization structure does not inhibit unconventional methods
c. Yes, but guidelines exist for proper procedures
d. No, bureaucratic structure inhibits informal transfer processes

3B1. How do individuals or organizations request funds for technology transfer projects? (D,A)

a. Streamlined procedures exist for funds requests
b. Written formal procedures similar to procedures for other corporate projects
c. Guidelines exist for methods to seek access to funds
d. Informal, political process is status quo
e. Unsure
f. Other: _____

3D1. Did this transfer action have a "product champion" to shepherd the technology through bureaucratic obstacles? (A)

a. Yes, the individual was a technical "expert"
b. Yes, the individual was a manager from the receiving organization
c. Yes, the individual was a high level manager
d. Yes, a transfer support organization
e. Yes, other:_____
f. No

4A1. Regarding the business unit the technology was transferred in to -- What is the business unit's principal industry? (A) _____

4B2. What description best fits your organization's personnel composition? (D,A)

a. Scientific -- mostly Ph.D.s
b. Science/Highly technical -- Many Ph.D.s and engineers
c. Highly technical -- Mostly engineers
d. Low technical -- Mostly engineers
e. Bureaucratic/Administrative
f. Other:_____

5A1. What is the distance between your organization and your transfer partner? (D,A)

a. Within 50 miles
b. Within 100 miles
c. Greater than 100 miles

6A1. How are technology transfer projects staffed? (D,A)

a. Fully dedicated teams
b. Teams are formed and time is made available, but project is an additional responsibility
c. Teams are formed but time is not set aside and project is an additional responsibility
d. No teams or dedicated time
e. Other:_____

6B1. How are technology transfer projects funded? (D,A)

a. Dedicated project funding
b. Technology transfer pools of money and projects compete for funds
c. Funds included in organizational accounts
d. No formal funding
e. Unsure
f. Other:_____

6B2. Do technology transfer projects compete against one another for funding? (D,A)

a. Yes, always
b. Yes, with exceptions
c. No

6C1. What best describes your organization's development research facilities? (A)

a. Exceptional facilities with plenty of space and good equipment
b. Adequate facilities for most applications
c. Inadequate facilities for most applications
d. No in house facilities exist
e. Other:_____

6C2. What best describes your organization's production facilities? (A)

a. Exceptional facilities with plenty of space and good equipment
b. Adequate facilities for most applications
c. Inadequate facilities for most applications
d. None, our organization specializes in research and development
e. None

6D1. At the time of the transfer, did your organization have personnel experienced in the subject technology? (A)

a. Yes, individual(s) are "experts"
b. Yes, individual(s) are adept in this technology area
c. Yes, individual(s) familiar with the technology
d. No, limited knowledge and experience
e. No

6E1. Does your organization have experienced development and production personnel? (A)

a. Experienced personnel in both product development and production
b. Experienced personnel in product development but not production
c. Experienced personnel in production but not product development
d. Weak in both areas
e. None

8A2. At what level is your T.T. organization? (A)

a. Located at corporate headquarters
b. Located at management offices of business units
c. Located at product center level offices
d. Located at corporate research facilities
e. Located at product development labs
f. No T.T. organization

8B1. What is the level of decision making authority in the T.T. organization? (D,A)

a. Complete decision making authority
b. Authority to make most decisions
c. Limited authority: projects are identified and tasked by higher authority
d. No authority

9A1. What is the T.T. experience of your organization (A)

a. History of numerous, highly complex T.T.s
b. Only recent involvement (less than 2 years) but some complex actions
c. Only recent involvement in less complex T.T.s
d. This was/is one of our first experiences

9A2. What is the complexity of this transfer relative to other transfers you are aware of? (A)

a. This transfer is more complex
b. This transfer similar in complexity to past actions
c. This transfer is less complex

9A3. What percent of sales comes from manufactured goods? (A) _____

9B1. Does a formal process plan exist for receiving technologies? (A)

a. Yes, formal process plan actively utilized and strictly adhered
b. Yes, process plan serves as a blueprint for T.T.
c. Yes, plan exists but it is rarely referenced or used
d. No written process plan

9C1. Does a business plan exist for commercializing technology? (A)

a. Yes, and it incorporates all aspects of bringing a product to market
b. Yes, and it appears most like a product marketing plan
c. Yes, but it is a tool used mostly by high level management
d. NO

9D1. Where do most of your technologies originate? (A)

a. Internal R&D
b. Externally - transferred in
c. Mix - Estimated ratio is __% internal, __% external

12D1. How is market research conducted on potential technology opportunities? (A)

a. Formal, intensive in-house market analysis
b. Informal in-house market analysis
c. Most often an external (contracted) market analysis is accomplished
d. Most often a market analysis is not conducted

13A1. How does the technology affect existing product markets? (D,A)

a. It creates a new market
b. It replaces existing products
c. It modifies or improves an existing product technology
d. It provides an equal, alternative approach to the status quo
e. It is a less sophisticated, low cost alternative

13B1. In regard to the technology, how can it be brought to the market? (D,A)

a. It is divisible -- it can be developed and included in products in small, less dramatic increments
b. Technology must be included as a complete package
c. Other:_____

13C1. How does the technology fit into the market(s)? (D,A)

a. Technology has multiple applications in several diverse markets
b. Technology has multiple applications in one market
c. Technology fits into one market
d. Market has not been identified

13DE1. How does the industry, the transfer, and other factors affect property rights? (D,A)

a. We own the property rights and any improvements to the technology (patent)
b. We own the property rights but the other party can patent improvements
c. Other party owns property rights, but we can patent improvements
d. We share patent rights with the other party
e. We have no ability to gain patent rights

14A1. What best describes the timing of this T.T. opportunity? (A)

a. The technology matched a current, existing need and resources available (funds, personnel)
b. The technology matched a current, existing need but resources were scarce
c. Resources available and technology may compliment one of our objectives
d. Resources available and technology development is a gamble (long shot)
e. Resources are scarce, and technology may compliment one of our objectives

14B1. How does the technology fit with existing business units and markets? (A)

a. Technology fits perfectly into a strategic objective or current project
b. Technology is related to an existing business unit or product
c. Technology provides an opportunity to use related expertise in new business/market areas
d. Technology does not fit existing business units or knowledge base

14C1. How do your personnel match the technology? (A)

a. Some personnel are "experts" in this technology area
b. Some personnel are "experts" in closely related technologies
c. Some personnel are familiar with this technology
d. Training or external assistance will be required to work with this technology

14C2. Regarding personnel familiar with the technology -- what is their strength(s)? (A)

a. Basic research
b. Technology development/maturation
c. Product Development
d. Manufacturing
e. Other or Combination:_____

15A1. Are interactions between the transfer partners maintained throughout a technology's and subsequently a product's lifecycle? (D,A)

a. Yes, scheduled, periodic meetings are held
b. Yes, interface is initiated on an "as needed" basis
c. No planned interface after initial transfer

15A3. Who typically interfaces with the transfer partner? (A)

a. Technology specialist on development team
b. High level corporate officer
c. Development team spokesperson (manager)
d. T.T. office

15C1. Did acquiring team seek input from the developer during cost and schedule estimate formulation? (D,A)

a. Yes, a member of the developing unit was an integral part of the cost and schedule estimation
b. Yes, input was requested from a member of the developing organization
c. Developing organization was not involved

15D2. At what point does a transfer benefit your organization? (A)

a. At point of technology transfer
b. At point of product/process development
c. At point product/process becomes financial success
d. It doesn't

15E1. Did your T.T. partners share personnel during the transfer and development? (D,A)

a. Yes
b. No

15F1. When did the developer and acquirer communicate technical aspects of the transfer? (D,A)

a. Long before the transfer was initiated
b. Close to the point of transfer
c. After the transfer agreement was initiated

Appendix E. Master Survey With Answers

Master

Survey

ATTRIBUTES OF SUCCESSFUL TECHNOLOGY TRANSFER

Administrative

1. Name: _____

2. Position: _____

3. Business Address: _____
   _____
   _____
   _____

4. Phone Number: _____

General

1. What is the most appropriate, most predominant name for the subject technology?

2. What technological discipline is it from?

3. Briefly describe the technology.

4. What is your role in technology transfer and/or technology development (inventor, technical point of contact, spokesperson, manager)?

5. How would you define technology transfer?

6. Does this case fit your description of technology transfer?

   a. Yes
   b. No
   Explain:_____

7. How would you define success in technology transfer?

8. In your opinion, rate the success of the technology transfer.

1 2 3 4 5 6 7 8 9 10

9. What level of maturity is the technology at the time of the transfer (ie basic)?

10. Has the maturity of the technology evolved since the beginning of the transfer?

11. If a commercial product is a goal of this technology transfer, has a product been developed?

Yes No

12. If you answered no, when do you estimated completion of a developed commercial product?_____

13. How would you describe the technology transfer process?

14. In your best judgment, when did the technology transfer process begin; end; is it still in progress?

15. Can you cite any examples of actions that may have improved the level of success of the transfer?

1) High Level Commitment (to overall T.T. policy)

1A1. Does your management team have a system for tracking technology transfer program progress? (D,A)

a. Yes, progress tracking is a highly visible, integral part of the technology transfer process. ***H***
b. Yes, I am aware of a system ***M***
c. Yes, but it is not regularly used ***M/L***
d. No ***L***

1A2. Does your management team keep abreast of technology transfer progress? (D,A)

a. Yes, frequent, planned meetings and/or reports are submitted to management ***H***
b. Yes, periodic, planned meeting and/or reports are submitted to management ***H/M***
c. Yes, infrequent, unplanned meetings and reports are requested from management ***M***
d. No ***L***

1B1. Are personnel located in your organization involved in seeking technology transfer opportunities? (D,A)

a. Yes, fully dedicated team ***H***
b. Yes, fully dedicated individual ***H/M***
c. Yes, included in the duties of personnel with other primary responsibilities ***M***
d. No ***L***

1B2. Are funds allocated for seeking technology transfer opportunities? (D,A)

a. Yes, separately funded portion of the corporate/organizational budget ***H***
b. Yes, part of some organizations' budgets but not separately funded ***M***
c. No funds allocated ***L***

1B3. Are facilities available to house technology transfer seeking activities? (D,A)

a. Yes, separate offices are provided for technology transfer personnel ***H***
b. Yes, space is provided for technology transfer personnel ***H/M***
c. Yes, but personnel remain in their functional office space ***M***
d. No ***L***

1C1. Does management have a written/formal plan for promoting technology transfer? (D)

a. Yes, plan is heavily promoted internally and outside the organization ***H***
b. Yes, plan is heavily promoted internally ***M***
c. Yes, plan is heavily promoted outside the organization ***M***
d. Yes, I have seen the plan ***M/L***
e. Yes, but I have not seen it ***L***
f. No ***L***

2) High Level Commitment (to specific transfer)

2A1. Do you feel that technology transfer is an important part of your job responsibility? (D,A)

a. Yes, highly important ***H***
b. Yes, moderately important ***H/M***
c. Somewhat important ***M***
d. No ***L***
e. No, specifically directed not to engage in technology transfer activities ***L***

2A2. Do you feel your organization is committed to technology transfer? (D,A)

a. Yes, highly committed ***H***
b. Yes, moderately committed ***M***
c. Somewhat ***M/L***
d. No ***L***

2B1. Are technology transfer projects allocated corporate financial resources? (D,A)

a. Yes, enough to do the job well ***H***
b. Yes, but limited funding reduces potential ***H/M***
c. Yes, but other funds necessary ***M***
d. No, must fund from organizational budgets ***M***
e. No ***L***

3) Informal Processes

3A1. Does your organization facilitate informal ways to exploit potential transfers? (D,A)

a. Yes, policy empowers employees to exploit technologies ***H***
b. Yes, organization structure does not inhibit unconventional methods ***H/M***
c. Yes, but guidelines exist for proper procedures ***M***
d. No, bureaucratic structure inhibits informal transfer processes ***L***

3B1. How do individuals or organizations request funds for technology transfer projects? (D,A)

a. Streamlined procedures exist for funds requests ***H***
b. Written formal procedures similar to procedures for other corporate projects ***H/M***
c. Guidelines exist for methods to seek access to funds ***M***
d. Informal, political process is status quo ***L***
e. Unsure ***L***
f. Other: _____

3C1. Did this transfer action have a "technology champion" to promote and shepherd the technology through bureaucratic obstacles? (D)

a. Yes, the individual was the inventor ***H/M***
b. Yes, the individual was the inventor's superior ***H/M***
c. Yes the individual was a high level manager ***H***
d. Yes, a transfer support organization assisted ***M***
e. Yes, other:_____
f. No ***L***

3D1. Did this transfer action have a "product champion" to shepherd the technology through bureaucratic obstacles? (A)

a. Yes, the individual was a technical "expert" ***H/M***
b. Yes, the individual was a manager from the receiving organization ***H /M***
c. Yes, the individual was a high level manager ***H***
d. Yes, a transfer support organization ***M***
e. Yes, other:_____
f. No ***L***

4) Strategic Fit (developer - acquirer)

4A1. Regarding the business unit the technology was transferred in to -- What is the business unit's principal industry? (A)_____

4A2. What military purpose was the technology designed for? (D)_____

4B2. What description best fits your organization's personnel composition? (D,A)

a. Scientific -- mostly Ph.D.s ***H***
b. Science/Highly technical -- Many Ph.D.s and engineers ***H***
c. Highly technical -- Mostly engineers ***H***
d. Low technical -- Mostly engineers ***M***
e. Bureaucratic/Administrative ***L***
f. Other:_____

5) Location

5A1. What is the distance between your organization and your transfer partner? (D,A)

a. Within 50 miles ***H***
b. Within 100 miles ***H/M***
c. Greater than 100 miles ***L***

6) Funding, staffing, and facilities

6A1. How are technology transfer projects staffed? (D,A)

a. Fully dedicated teams ***H***
b. Teams are formed and time is made available, but project is an additional responsibility ***H/M***
c. Teams are formed but time is not set aside and project is an additional responsibility ***M***
d. No teams or dedicated time ***L***
e. Other:_____

6B1. How are technology transfer projects funded? (D,A)

a. Dedicated project funding ***H***
b. Technology transfer pools of money and projects compete for funds ***H/M***
c. Funds included in organizational accounts ***M***
d. No formal funding ***L***
e. Unsure ***L***
f. Other:_____

6B2. Do technology transfer projects compete against one another for funding? (D,A)

a. Yes, always ***H***
b. Yes, with exceptions ***M***
c. No ***L***

6C1. What best describes your organization's development research facilities? (A)

a. Exceptional facilities with plenty of space and good equipment ***H***
b. Adequate facilities for most applications ***M***
c. Inadequate facilities for most applications ***M/L***
d. No in house facilities exist ***L***
e. Other:_____

6C2. What best describes your organization's production facilities? (A)

a. Exceptional facilities with plenty of space and good equipment ***H***
b. Adequate facilities for most applications ***M***
c. Inadequate facilities for most applications ***M/L***
d. None, our organization specializes in research and development ***L***
e. None ***L***

6D1. At the time of the transfer, did your organization have personnel experienced in the subject technology? (A)

a. Yes, individual(s) are "experts" ***H***
b. Yes, individual(s) are adept in this technology ***H/M***
c. Yes, individual(s) familiar with the technology ***M***
d. No, limited knowledge and experience ***M/L***
e. No ***L***

6E1. Does your organization have experienced development and production personnel? (A)

a. Experienced personnel in both product development and production ***H***
b. Experienced personnel in product development but not production ***M***
c. Experienced personnel in production but not product development ***M***
d. Weak in both areas ***L***
e. None ***L***

6F1. What best describes the support capabilities (patent assistance, marketing, administration) of the technology developing organization? (D)

a. Organization has a well staffed transfer support function to include patent assistance, project control, marketing, and administration ***H***
b. Organization has a support staff that provides assistance ***M***
c. Organization has support which seems to hinder progress ***L***
d. No support function ***L***

6G1. What best describes the capabilities of the acquiring organization in respect to development and project control? (D)

a. Organization has ample resources to support development, project control, manufacturing, and marketing ***H***
b. Organization has resources in most areas but may lack in some ***M***
c. Less than adequate capabilities ***L***

7) Experienced technology transfer organization and strategy (developer).

7A1. What is the closeness of the transfer agent to the developing organization? (D)

a. Same person ***H***
b. Close associate with similar technical expertise ***H/M***
c. Located in the same organization ***M***
d. From a separate transfer organization ***M/L***
e. Outside party ***L***

7-8A2. How close is the T.T. organization to the technology development organization? (D)

a. T.T. organization is part of technology development lab ***H***
b. T.T. organization is part of lab headquarters ***M***
c. T.T. organization is external to the lab ***M/L***
d. T.T. organization is an outside party (contracted) ***L***
e. Other: _____

7B1. Does the developing organization have a written process plan for T.T.? (D)

a. Yes, formal process plan actively utilized and strictly adhered ***H***
b. Yes, process plan serves as a blueprint for T.T. ***M***
c. Yes, plan exists but it is rarely referenced or used ***M/L***
d. No written process plan ***L***

7B2. At what level was the plan established? (D)

a. high level management level ***H***
b. middle management level ***M***
c. immediate organization ***H/M***
d. other: _____

7C1. What best describes developer involvement in the T.T. process? (D)

a. Mostly technical and administrative duties ***M***
b. Mainly technical responsibilities ***H***
c. Level of involvement varies from project to project ***H/M***

7D1. Is developer allowed to dedicate "company" time to transfer projects? (D)

a. Yes, involvement is part of the job responsibility and it is highly encouraged ***H***
b. Yes, involvement on "official" projects encouraged ***H/M***
c. Yes, but other job responsibilities maintain priority ***M***
d. No ***L***

7E1. What is the T.T. experience level of your organization? (D)

a. History of numerous, highly complex T.T.s ***H***
b. Only recent involvement (less than 2 years) but some complex actions ***H/M***
c. Only recent involvement in less complex T.T.s ***M***
d. This was/is one of our first experiences ***L***

7E2. What is the complexity of this transfer relative to other transfers you are aware of? (D)

a. This transfer is more complex ***L***
b. This transfer similar in complexity to past actions ***M***
c. This transfer is less complex ***H***

8) Centralized Support/Decentralized Action

8A1. 7-8A2

8A2. At what level is your T.T. organization? (A)

a. Located at corporate headquarters ***M***
b. Located at management offices of business units ***M***
c. Located at product center level offices ***H/M***
d. Located at corporate research facilities ***M***
e. Located at product development labs ***H***
f. No T.T. organization ***L***

8B1. What is the level of decision making authority in the T.T. organization? (D,A)

a. Complete decision making authority ***H***
b. Authority to make most decisions ***H/M***
c. Limited authority: projects are identified and tasked by higher authority ***M***
d. No authority ***L***

9) Product Development and Commercialization Experience (Acquirer)

9A1. What is the T.T. experience of your organization (A)

a. History of numerous, highly complex T.T.s ***H***
b. Only recent involvement (less than 2 years) but some complex actions ***H/M***
c. Only recent involvement in less complex T.T.s ***M***
d. This was/is one of our first experiences ***L***

9A2. What is the complexity of this transfer relative to other transfers you are aware of? (A)

a. This transfer is more complex ***L***
b. This transfer similar in complexity to past actions ***M***
c. This transfer is less complex ***H***

9A3. What percent of sales comes from manufactured goods? (A)_____

9B1. Does a formal process plan exist for receiving technologies? (A)

a. Yes, formal process plan actively utilized and strictly adhered ***H***
b. Yes, process plan serves as a blueprint for T.T. ***M***
c. Yes, plan exists but it is rarely referenced or used ***M/L***
d. No written process plan ***L***

9C1. Does a business plan exist for commercializing technology? (A)

a. Yes, and it incorporates all aspects of bringing a product to market ***H***
b. Yes, and it appears most like a product marketing plan ***M***
c. Yes, but it is a tool used mostly by high level management ***M/L***
d. No ***L***

9D1. Where do most of your technologies originate? (A)

a. Internal R&D ***L***
b. Externally - transferred in ***H***
c. Mix - Estimated ratio is __% internal, __% external ***M***

10) Entrepreneurial

10A1. How does your organization market technologies? (D)

a. Effort directed only at relevant, targeted industries ***H***
b. Use same publications and methods regardless of the technology ***M***
c. Combination of (a) and (b) ***H/M***
d. No formal marketing ***L***

10B1. Do you further develop technologies, beyond internal requirement, solely for T.T. potential? (D)

a. Yes, we internally support technology maturation for T.T. purposes ***H***
b. Yes, we contract for technology maturation for promising technologies ***H/M***
c. No, we do not further develop technologies beyond internal requirements ***L***

10C1. What T.T. vehicles are used? (D)

a. CRDAs
b. Licensing
c. SBIRs
d. No vehicles used - informal process ***L***
e. Combination: ***H***

10C2. Any incentive arrangements granted to acquirers to encourage T.T.? (D)

a. Exclusive rights ***M***
b. Patents ***M***
c. Funds ***M***
d. Personnel ***M***
e. All of the above ***H***
f. Combination: ***H/M***
g. None ***L***

11) Science and technology staffs.

11A1. What is the level of participation of developers in the T.T. process? (D)

a. Formal responsibilities delineated in T.T. plans and strategy documents ***H***
b. Participation part of job responsibilities and it is highly encouraged ***H/M***
c. Participate if time allows ***M***
d. Hand off knowledge and technology and return to normal duties ***L***

11-15B1. Are developers incentivized to see technologies commercialized? (D)

a. Inventors receive royalties based upon commercial success ***M***
b. Royalties returned directly to benefit developing unit ***M***
c. Developers allowed life-cycle involvement in projects ***M***
d. All of the above ***H***
e. Combination: ***H/M***

11C1. How are potential developers (inventors) encouraged to develop technologies? (D)

a. Citations and rewards sponsored by management
b. Achievers submitted for monetary rewards
c. Achievers are submitted for national rewards
d. Projects granted "extra" funding
e. All of the above ***H***

11D1. Are developers actively involved in their professional community? (D)

a. Expected to participate in conferences, publish, and interact with colleagues (funds are easily granted) ***H***
b. Encouraged to participate in conferences, publish, and interact with colleagues (funds are easily granted) ***H/M***
c. Involvement accepted but funds are not easily obtained ***M***
d. No funds allocated ***L***

11D2. Are you aware of any T.T. opportunities arising from professional community involvement? (D)

a. Yes, several ***H***
b. Yes ***M***
c. No ***L***

11E1. Does lab have a recognition process for developers and key participants? (D)

a. For those instrumental in technological breakthroughs
b. For those instrumental in incremental technology, product, or process improvements
c. For those who facilitate T.T.
d. For those instrumental in affecting commercial success of technology
e. All of the above ***H***
f. Other: _____

12) Technology evaluation and patenting.

12A1. Does organization have incentives for identifying intellectual property? (D)

a. Awards and money available for those who identify intellectual property ***H***
b. Personnel trained and encouraged to identify intellectual property ***M***
c. No ***L***

12B1. Does organization have a trained support staff for the patent process? (D)

a. Yes, an office has sole responsibility for administering patenting process ***H***
b. Yes, a specific individual(s) in the legal office handles this function ***H/M***
c. Yes, an office supports but it is a shared effort ***M***
d. Yes, a legal office supports but developing unit does the work ***M/L***
e. No ***L***

12C1. Does industry have the opportunity to identify fruitful technologies from your laboratory? (D)

a. Yes, all research projects are abstracted and made available to industry ***M***
   Where: _____
b. Yes, industry allowed access to lab facilities to see opportunities first hand ***H***
c. Yes, T.T. specialists review lab technologies ***H/M***
d. No ***L***

12D1. How is market research conducted on potential technology opportunities? (A)

a. Formal, intensive in-house market analysis ***H***
b. Informal in-house market analysis ***M***
c. Most often an external (contracted) market analysis is accomplished ***M/L***
d. Most often a market analysis is not conducted ***L***

12D2. How is market research conducted on technologies (D)

a. A formal, intensive in-house market research ***H***
b. An informal in-house analysis ***M***
c. Most often, market analysis is contracted out ***M/L***
d. Most often this task is left for the acquirer ***L***

12E1. Are inventors requested to identify potential markets or interested firms? (D)

a. Inventors often tasked to identify potential contacts ***H***
b. Inventor input is sometimes requested ***M***
c. Rarely is the inventor involved ***L***

13) Qualities of commercial adaptability (technology).

13A1. How does the technology affect existing product markets? (D,A)

a. It creates a new market ***H***
b. It replaces existing products ***H***
c. It modifies or improves an existing product technology ***H/M***
d. It provides an equal, alternative approach to the status quo ***M***
e. It is a less sophisticated, low cost alternative ***M***

13B1. In regard to the technology, how can it be brought to the market? (D,A)

a. It is divisible -- it can be developed and included in products in small, less dramatic increments ***H***
b. Technology must be included as a complete package ***L***
c. Other:_____

13C1. How does the technology fit into the market(s)? (D,A)

a. Technology has multiple applications in several diverse markets ***H***
b. Technology has multiple applications in one market ***H/M***
c. Technology fits into one market ***M***
d. Market has not been identified ***L***

13DE1. How does the industry, the transfer, and other factors affect property rights? (D,A)

a. We own the property rights and any improvements to the technology (patent) ***H***
b. We own the property rights but the other party can patent improvements ***H/M***
c. Other party owns property rights, but we can patent improvements ***H/M***
d. We share patent rights with the other party ***M***
e. We have no ability to gain patent rights ***L***

14) Strategic fit (technology - acquirer).

14A1. What best describes the timing of this T.T. opportunity? (A)

a. The technology matched a current, existing need and resources available (funds, personnel) ***H***
b. The technology matched a current, existing need but resources were scarce ***M***
c. Resources available and technology may compliment one of our objectives ***H/M***
d. Resources available and technology development is a gamble (long shot) ***M***
e. Resources are scarce, and technology may compliment one of our objectives ***L***

14B1. How does the technology fit with existing business units and markets? (A)

a. Technology fits perfectly into a strategic objective or current project ***H***
b. Technology is related to an existing business unit or product ***H/M***
c. Technology provides an opportunity to use related expertise in new business/market areas ***M***
d. Technology does not fit existing business units or knowledge base ***L***

14C1. How do your personnel match the technology? (A)

a. Some personnel are "experts" in this technology area ***H***
b. Some personnel are "experts" in closely related technologies ***H/M***
c. Some personnel are familiar with this technology ***M***
d. Training or external assistance will be required to work with this technology ***L***

14C2. Regarding personnel familiar with the technology -- what is their strength? (A)

a. Basic research ***B***
b. Technology development/maturation ***T***
c. Product Development ***D***
d. Manufacturing ***M***
e. Other or Combination: ***C*** _____

15) Life-cycle interaction

15A1. Are interactions between the transfer partners maintained throughout a technology's and subsequently a product's lifecycle? (D,A)

a. Yes, scheduled, periodic meetings are held ***H***
b. Yes, interface is initiated on an "as needed" basis ***M***
c. No planned interface after initial transfer ***L***

15A2. Who typically interfaces with the transfer partner? (D)

a. Inventor ***H***
b. Someone close to the technology ***H/M***
c. Organization spokesperson ***M***
d. T.T. organization ***M/L***
e. Other: _____

15A3. Who typically interfaces with the transfer partner? (A)

a. Technology specialist on development team ***H***
b. High level corporate officer ***H/M***
c. Development team spokesperson (manager) ***M***
d. T.T. office ***L***

15B1. -- 11-15B1.

15C1. Did acquiring team seek input from the developer during cost and schedule estimate formulation? (D,A)

a. Yes, a member of the developing unit was an integral part of the cost and schedule estimation ***H***
b. Yes, input was requested from a member of the developing organization ***M***
c. Developing organization was not involved ***L***

15D1. At what point does a transfer benefit your organization? (D)

a. At point of technology transfer ***L***
b. At point of product/process development ***M***
c. At point product/process becomes financial success ***H***
d. It doesn't ***L***

15D2. At what point does a transfer benefit your organization? (A)

a. At point of technology transfer ***L***
b. At point of product/process development ***M***
c. At point product/process becomes financial success ***H***
d. It doesn't ***L***

15E1. Did your T.T. partners share personnel during the transfer and development? (D,A)

a. Yes ***H***
b. No ***L***

15F1. When did the developer and acquirer communicate technical aspects of the transfer? (D,A)

a. Long before the transfer was initiated ***H***
b. Close to the point of transfer ***M***
c. After the transfer agreement was initiated ***L***

Appendix F: Technology Transfer Attribute Survey Data

TECHNOLOGY TRANSFER ATTRIBUTE SURVEY DATA

	Samples	Developer																																		
		1A1	1A2	1A	1B1	1B2	1B3	1B	1C1	1	2A1	2A2	2A	2B1	2	3A1	3B1	3C1	3	4B2	4	5A1	5	6A1	6B1	6B2	6B	6F1	6G1	6	7A1	7A2	7A	7B1	7B2	7B	7C1
S	(WL1)	H	H	H	H/M	M	H/M	M+	M	M+	H	H	H	H/M	H-	H	L	H/M	M+	H	H	H	H	M/L	L	H	L	L	L	L	H	H	H	L	H	M	M
S	(WL2)	H	H	H	H/M	M	H/M	M+	M	M+	H	H	H	H/M	H-	H	L	H/M	M+	H	H	H	H	M/L	L	H	L	L	M	L+	H	H	H	L	H	M	M
S	(AL1)	M	H/M	M+	H/M	L	M	M-	L	M-	H	M	H-	L	M-	M	L	M	M-	H	H	L	L	L	H	M	M	M	H	M+	H/M	H	H	M	H	H-	M
S	(WL4)	H	L/M	M+	M	L	H/M	M-	L	M-	H	H	H	M	H-	H	L	H	M+	H	H	H	H	L	M	L	M	L	H	M+	H	H	H	M/L	H	M+	H
S	(AL3)	H	H	H	L	L	M	L+	L	M-	H	M/L	M+	L	M-	L	L	H/M	M-	H	H	L	L	L	M	L	M	L	H	M-	H	H	H	H	H	M	
S	(WL15)	M/L	M	M-	H	M	M	M+	L	M-	H	H	H	H/M	H-	H	M	H	H-	H	H	H	H	M	L	L	L	M	M	M-	L	H	M	H	H/M	H-	M
PS	(AL2)	M	H/M	M+	H/M	L	M	M-	L	M-	H	M	H-	L	M-	H/M	L	H	M+	H	H	L	L	L	H	M	M	M	H	M+	H	H	H	M	H	H-	M
PS	(WL3)	M	H/M	M+	M	L	H/M	M-	L	M-	H	M	H-	M	M+	H	L	H/M	M+	H	H	H	H	M	M	L	M	M	M	M	L/M	L/M	M-	L	L	L	H
PS	(WL8)	M	M	M	M	L	L	L+	L	L+	H/M	M	M+	L	M-	H	H/M	L	M+	H	H	H	H	H/M	L	N/A	L	H	L	M	M	M	M	M	H/M	M+	M
PS	(WL9)	M	M	M	M	L	L	L+	L	L+	H/M	M	M+	L	M-	H	H/M	H/M	H-	H	H	H	H	H/M	L	N/A	L	L	L	L+	M	M	M	M	H/M	M+	M
PS	(AL5)	H	M	H-	H/M	L	H	M+	L	M	H	M	H-	H	H-	H	L	H/M	M+	H	H	L	L	M/L	L	L	L	L	M	L+	H	H	H	H	M	H-	M
PS	(WL13)	M	M	M	M	L	L	L+	M/L	M-	H/M	M	M+	H	H-	H/M	M	H/M	M+	H	H	L	L	M	L	L	L	L	M	M	L	L	L	L	L	L	H
PS	(AL4)	M/L	M	M-	H/M	M	H/M	M+	M/L	M	H	M	H-	M	M+	H	L	H/M	M+	H	H	L	L	M	L	L	L	M	M	M-	H	H	H	L	L	H/M	
PS	(WL14)	M	H/M	M+	H/M	M	H/M	M+	L	M	M	M	M	M	M	M	L	H/M	M-	H	H	H	H	M/L	L	L	L	M	M	M-	L	L	L	M	H/M	M+	H
F	(WL5)	H	H/M	H-	H/M	H	H/M	H-	H/M	H-	H	H/M	H-	M	M+	H	L	H	M+	H	H	H/M	H-	M	M	L	M	H	M	M+	H	L	M	H/M	H/M	H-	H
F	(WL6)	L	L	L	L/M	L	M	M-	L	L	H	M	H-	M	M+	H/M	L	H/M	M	H	H	H/M	H-	M	M	L	M	M	M	M	H	H	H	L	L	L	H
F	(WL7)	H	H/M	H-	H	H	H	H	L	M+	H	M	H-	H/M	H-	H/M	H/M	M	M+	H	H	H	H	M/L	H/M	M	H-	M	M	M	M/L	H	M+	M	H/M	M+	L
F	(WL10)	H	H/M	H-	H/M	H	M	H-	H	H-	H	H	H	H	H	H	M	H	H-	H	H	H/M	H-	H	H	L	H	M	M	H-	L	L	L	H	H	H	M
F	(WL12)	M/L	M	M-	L	L	L	L	L	L+	L	M/L	L+	M	M-	M	M	H/M	M+	H	H	H	H	H/M	M	L	M	M	M	M	L	L	L	H	H	H	H

	Samples	Developer																																		
		7D1	7E1	7E2	7E	7	8A2	8B1	8	10A	10B	10C	10C	10C	10	11A	11B	11C	11D	11D	11D	11E	11	12A	12B	12C	12D	12E	12	15A	15A	15A	15B	15C	15D	15E	15F1	15
S	(WL1)	H	H/M	L	M-	M+	H	H	H	M	H/M	H	H	H	H-	H/M	H	H	H/M	M	M+	H	H-	H	M	M	L	M	M	M	H	H-	H	L	L	H	H	M+
S	(WL2)	H	H/M	M	M+	H-	H	H	H	M	H/M	H	H	H	H-	H/M	H	H	H/M	M	M+	H	H-	H	M	M	L	M	M	M	H/M	H-	H	M/L	L	H	H	M+
S	(AL1)	H	H	M	H-	H-	H	H/M	H-	H	L	H	H	H	M+	H/M	H/M	H	H	M	H-	H	H-	L	L	M	L	L	L+	H	H	H	H/M	H	L	H	H	M+
S	(WL4)	H	H	H	H	H	H	H/M	H-	L	L	H	L	M	L+	H/M	H	L	H	L	M	H	M+	L	L/M	M	M	M	M-	L	H/M	M-	H	L	H	H	H	H-
S	(AL3)	H	L	M	M-	H-	H	H/M	H-	H/M	H/M	H	L	M	M+	H	L	H	H	H	H	M	M+	L	L	M	L	M	L+	H	H	H	L	H	L	H	H	M+
S	(WL15)	H	H	L	M	M+	H	H/M	H-	H/M	H	H/M	M	M+	H-	H/M	H/M	M	H/M	L	M-	H	M+	H	M/L	M	M/L	M	M	M	H/M	M+	H/M	H	L	H	H	M+
PS	(AL2)	H	H	L	M	H-	H	H/M	H-	H	L	H	H	H	M+	H/M	H/M	H	H	M	H-	H	H-	L	L	M	L	L	L	H	H	H	H/M	L	L	L	H	M
PS	(WL3)	M	H/M	H	H-	M	L/M	L	L+	H/M	H	H	H	H	H-	M	H/M	H	H/M	H	H-	H	H-	H	H	L	L	L	M-	H	H	H	H/M	H	H	H	M	H-
PS	(WL8)	H	M	M	M	M+	M	M	M	H	L	H	H	H	M+	H/M	M	L	H/M	L	M-	M	M	L	L	M	L	M	L+	L	H/M	M-	M	L	H	H	H	M+
PS	(WL9)	H	M	H	H-	M+	M	M	M	H	L	H	H	H	M+	H/M	M	L	H/M	L	M-	M	M	L	L	M	L	M	L+	L	H	M	M	L	H	H	H	M+
PS	(AL5)	H	H	L	M	H-	H	H/M	H-	H/M	H	H	H	H	H-	H/M	H/M	H	H	H	H	H	H-	L	L	H	H	H	M+	H	H	H	H/M	H	L	H	M	M+
PS	(WL13)	H	H/M	H	H-	M+	L	H	M	M	L	H	H	H	M	H/M	M	M/L	H	L	M	L	M-	H	M	M	L	H	M+	M	H	H-	M	L	M	L	H	M
PS	(AL4)	H	L	H	M	M+	H	H	H	L	L	H	M	H-	M-	H	M	M	H	H	H	H/M	H-	L	H/M	H	L	M	M	M	H	H-	M	H	H	H	H	H-
PS	(WL14)	M	H	H	H	M+	L	M	M-	H/M	L	H	M	H-	M	H/M	M	L	H	L	M	M	M	H	H/M	H	L	L	M	M	H/M	M+	M	L	L	H	H	M
F	(WL5)	H/M	M	M	M	M+	L	H	M	M	L	H	H	H	M	H/M	H/M	M	H	H	H	H	H-	M/L	M	H/M	L	L	M-	H	H	H	H/M	M	M	L	H	M+
F	(WL6)	H	H	M	H-	H-	H	H	H	M	H	H	H	H	H-	H/M	H/M	H/M	H	H	H	H	H-	H	H	H	L	M	M+	L	H	M	H/M	L	H	L	H/M	M
F	(WL7)	L	H	M	H-	M-	H	H/M	H-	H/M	H/M	H	H	H	H-	M	H	M	H	L	M	H	M+	H	M	H	H	H	H	M/L	M+	H	L	M	L	H	M
F	(WL10)	H	H/M	L	M-	M+	L	H	M	M	H	H	H	H	H-	H	H/M	L	H	H	H	L	M	L	M	M	M	H	M	M	H	H-	H/M	H	M	L	H	H-
F	(WL12)	H/M	L	H	H-	M+	L	L	L	L	L	H	H	H	M	L	H/M	L	H/M	M	M+	L	M-	H/M	H	H	L	L	M	M	H/M	M+	H/M	L	H	H	L	M+

	TECHNOLOGY TRANSFER ATTRIBUTE SURVEY DATA																												
	Samples	Acquirer																											
		1A1	1A2	1A	1B1	1B2	1B3	1B	1	2A1	2A2	2A	2B1	2	3A1	3B1	3D1	3	4B2	4	5A1	5	6A1	6B1	6B2	6B	6C1	6C2	6C	6D1
S	(WL1)	H/M	H/M	H-	H/M	M	H/M	M+	M+	H	H	H	H	H	H	L	H	M+	H	H	H/M	H-	M	H/M	H	H-	M	H	H-	H/M
S	(WL2)	H	H	H	M	M	M	M	H-	M	M/L	M-	H	M+	H	H/M	H/M	H-	H	H	H	H	H	H	M	H	M	M	M	H/M
S	(AL1)	H	H	H	H	H	M	H-	H	H	H	H	M	H-	H/M	H/M	H/M	H-	H	H	L	L	H	H	H	H	H	H	H	M/L
S	(WL4)	H	H	H	L	L	L	L	M	M	H	H-	H	H-	H	H	H	H	H	H	H	H	H	L	H	M	H	H-	H	
S	(AL3)	L	M	M-	M	M	M	M	M-	H/M	M/L	M	M	M	L	H/M	H	M+	H	H	L	L	L	L	L	M	M	M	H	
S	(WL15)	H	H/M	H-	M	H/M	H/M	M+	H-	H	H	H	H/M	H-	H/M	H/M	H/M	H-	H	H	L	L	M/L	H	H	H	L	L	L	H
PS	(AL2)	H	H	H	M	L	M	M-	M+	H/M	M	M+	M	M	H/M	L	H/M	M	H	H	L	L	M/L	H	H	H	H	M/L	M+	H/M
PS	(WL3)	M/L	H	M+	M	H	M	M+	M+	H/M	H	H-	M	M+	H/M	L	H	M+	H	H	H	H	M/L	L	L	L	M/L	M	M-	M
PS	(WL8)	H	H	H	H/M	M	H	H-	H-	H	H	H	H	H	M	M	H/M	M+	H	H	H/M	H-	H	M	L	M	M	M	M	H
PS	(WL9)	H	H	H	M	L	L	L+	M+	H	H	H	H	H	H	H	H	H	H	H	H	H	H/M	L	L	L	L	L	L	L
PS	(AL5)	L	L	L	M	M	L	M-	L+	L	M	M-	M	M-	H	M	H/M	H-	H	H	L	L	M	H	L	H	M/L	M	M-	M
PS	(WL13)	L	M	M-	M	L	L	L+	L+	H/M	M/L	M	H	H-	H/M	L	H/M	M	H	H	H	H	M	M	L	M	M	M	M	M/L
PS	(AL4)	M/L	H/M	M	M	L	M	M-	M	L	M/L	L+	M	M-	H/M	L	H/M	M	H	H	L	L	M/L	M	L	M	M	M	M	H
PS	(WL14)	L	L	L	M	L	L	L+	L+	H/M	L	M-	M	M	H	L	H	M+	L	L	H	H	M/L	L	L	L	L	L	L	M/L
F	(WL5)	M/L	L	L+	M	M	L	M-	L+	H/M	M	M+	H/M	M+	H/M	H	H	H	H	H	H/M	H-	M/L	L	H	L	L	H	M	H
F	(WL6)	M/L	M	M-	M	L	M	M-	M-	H/M	H	H-	H/M	H-	H/M	H	H/M	H-	M	M	H/M	H-	M	H/M	H	H-	M	M	M	H/M
F	(WL7)	H	H	H	M	M	M	M	H-	M	M/L	M-	M	M	H/M	M	H	H-	M	M	H	H	H	H/M	H	H-	M	M	M	M
F	(WL10)	L	M	M-	L	L	M	L+	L+	M	M	M	H/M	M+	H/M	L	H/M	M	H	H	H/M	H-	M	L	M	L	M	M	M	L
F	(WL12)	H/M	H/M	H-	L	L	L	L	M-	M	M/L	M-	M	M	L	L	H	M-	H	H	H/M	H-	M/L	M	L	M	M	M	M	H/M
	Samples	Acquirer																											
		6E1	6	8A2	8B1	8	9A1	9A2	9A3	9A	9B1	9C1	9D1	9	12D	12	14A1	14B1	14C	14C	14C	14	15A1	15A3	15A	15C	15D	15E1	15F1	15
S	(WL1)	H	H-	M	H	H-	H	M	M	M+	M	H	M	M+	M	M	H/M	H	H/M	C	H-	H-	H	H	H	H	H	H	H	H
S	(WL2)	H	H-	M	H/M	M+	M	L	M/L	M-	M	M	M	M	H	H	M	H/M	M	D	M+	M	H	H	H	M	H	H	M	H-
S	(AL1)	H	H-	M	H/M	M+	H	L	M	M	L	H	M	M	H	H	M	M	M	C	M	M	H	M	H-	M	H	H	M	H-
S	(WL4)	L	H-	L	L	L	L	M	L	L+	L	H	L	M-	M	M	H	H	H	C	H	H	M	M	M	L	H	H	L	M
S	(AL3)	H	M	L	L	L	L	M	L	L+	L	M	H	M	M	M	H/M	H	H	B	H	H	M	H-	H	H	H	H	H	
S	(WL15)	M	L	M	M	M	H	L	L	M-	L	M/L	H	M-	M	M	M	M	H/M	B	H-	M+	H	H	H	H	L	H	H	H-
PS	(AL2)	H	H-	M	M	M	H	L	M/L	M-	L	H	L	M-	M	M	H	H	H/M	C	H	H	M	H	H-	L	H	L	L	M-
PS	(WL3)	H	M	M	H	H-	L	M	H	M	L	H	L	M-	M	M	M	M	M	D	M	M	M	H/M	M+	M	H	H	H	H-
PS	(WL8)	H	H-	M	H	H-	H	L	H/M	M+	M	H	L	M	M	M	H	H	H	C	H	H	H	H	H	H	L	L	M	M
PS	(WL9)	M	M-	M	H	H-	L	H	H	M+	L	M	L	M-	M	M	H	H	H	D	H	H	H	H/M	H-	H	H	L	H	H-
PS	(AL5)	H	M+	H/M	M	M+	H/M	M	H	H-	L	M	H	M	M	M	H/M	M	M	D	M	M+	M	H	H-	M	H	L	L	M
PS	(WL13)	M	M	L	H	M	L	M	H	M	L	L	M	M-	M	M	M	L	L	D	L	L+	M	M	M	H	H	H	M	H-
PS	(AL4)	H	M+	M	H	H-	L	M	H	M	L	H	L	M-	H	H	M	H	H	C	H	H-	M	H/M	M+	M	H	H	M	M+
PS	(WL14)	M	L+	L	L	L	L	M	L	L+	L	H	L	M-	M/L	M-	M	H	M	T	M	M+	L	H	M	L	H	L	H	M
F	(WL5)	M	M	L	H	M	H/M	M	H	H-	L	L	M	M-	M	M	M	H	H	C	H	H-	L	H/M	M-	L	M	L	M	M-
F	(WL6)	H	M+	M	H	H-	H	H	H	H	L	L	M	M-	M	M	M	H	H	D	H	H-	M	H	H-	H	H	L	H	H-
F	(WL7)	H	H-	H/M	M	M+	H/M	L	M	M-	M	H	M	M+	H	H	H	M	M	T	M	M+	M	M	M	M	H	L	H	M+
F	(WL10)	L	L+	L	H/M	M-	L	H	H	M+	L	L	L	L+	L	L	M	H	H/M	D	H-	H-	L	H	M	M	M	L	H	M
F	(WL12)	H	M+	L	L	L	L	L	H	M-	L	L	L	L+	M	M	H	H	M	D	M	H-	M	H/M	M+	M	H	L	H	M+

TECHNOLOGY TRANSFER ATTRIBUTE SURVEY							
	Samples	Technology					
		13A1	13B1	13C1	13D1	13E1	13
S	(WL1)	H/M	H	H	M	M	H-
S	(WL2)	H	M	H	L+	M-	M+
S	(AL1)	H	L	H	H/M	H/M	M+
S	(WL4)	H	L	M	M	M	M+
S	(AL3)	H/M	H	H	M	M	H-
S	(WL15)	H	M	H/M	M/L	M/L	M
PS	(AL2)	H	H	H	M/L	M/L	M+
PS	(WL3)	H	L	H	H/M	H/M	M+
PS	(WL8)	H/M	M	H	H	H/M	H-
PS	(WL9)	H/M	M	M	H	H/M	M+
PS	(AL5)	H	H	H	H	H	H-
PS	(WL13)	H	L	M	M	M	M
PS	(AL4)	H/M	L	H	H/M	H/M	M+
PS	(WL14)	H/M	H	H	M	M	H-
F	(WL5)	H/M	M	H/M	H/M	H/M	H-
F	(WL6)	H/M	H	H	M-	L+	M+
F	(WL7)	H	M	H-	M	M-	M+
F	(WL10)	H/M	H	H	M	M	H-
F	(WL12)	H/M	H	H	H/M	H	H-

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Vita

First Lieutenant James B. Rose, a Florida native, received his undergraduate degree from Florida State University. In 1991, he graduated with a Bachelor of Science in Business, majoring in Purchasing and Materials Management, and Multinational Business Operations. Upon Reserve Officer Training Corps commission into the United States Air Force, First Lieutenant Rose was assigned to the 502d Contracting Squadron at Maxwell Air Force Base, Alabama.

In addition to outstanding performance as a procurement officer, First Lieutenant Rose developed the Air Education and Training Command's first base-level Contracting Customer Service Center. While in charge of the Customer Service Center, Lt. Rose conducted base-wide customer education and insured optimum contracting support during critical fiscal year-end close-out procedures.

In 1994, First Lieutenant Rose was assigned to the Air Force Institute of Technology, where he graduated in 1995 with a Masters degree in Contracting Management. Upon completion of the Master's program, Lt. Rose was assigned to the 37th Flying Training Squadron, Columbus Air Force Base, Mississippi for Specialized Undergraduate Pilot Training.

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13. ABSTRACT *(Maximum 200 words)*

By definition, federal-to-commercial technology transfer is the ability to leverage national investments in technology beyond their traditional customer base. The technology can be physical devices, processes, knowledge, or proprietary information. Unfortunately, and despite exhaustive legislative efforts, US industry has fallen behind its competitors in the application of federal technologies to commercial uses. However, research indicates that some organizations routinely experience successful technology transfer actions. In fact, studies identify a gap between the technology transfer rates of some universities and government laboratories.

The objective of this thesis effort is to pinpoint techniques which may improve Air Force technology transfer. First, previous literature is utilized to identify attributes associated with successful technology transfers. Surveys, which define the presence of successful attributes, are personnally administered to key individuals on acquiring and developing teams of Air Force laboratory sponsored technology transfer projects. Data from 19 technology transfer projects are analyzed. Results of the analysis pinpoint techniques which can be used to improve Air Force technology transfer strategies.

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